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Poised for Profit

Clean Energy

Next High Tech Industry

Job Surge

Acknowledgements

Climate Solutions, a Northwest non-profit organization, works to establish the Pacific Northwest as a world leader in the development and export of clean energy technologies. Climate Solutions focuses on the introduction of innovative, practical and profitable solutions for the clean energy needs of today and for generations to come, thus bringing economic opportunity to the region.

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POISED FOR PROFIT:

How Clean Energy Can Power the Next High-Tech Job Surge in the Northwest

EXECUTIVE SUMMARY

A market analysis commissioned by a prominent group of Pacific Northwest utilities and economic development agencies has concluded that the Pacific Northwest has the opportunity to be a global leader in the technology-based clean energy industry. This emerging industry will bring valuable jobs and economic development benefits to the region.

High Tech DÉJÀ VU

Clean energy today is at the cutting edge of energy technology just as information technology and biotechnology were the vanguard twenty years ago, sweeping through the West Coast and transforming economies in their wake. A group of small businesses launched in garages and research labs changed the way we work, the way we treat diseases, and the way we communicate with each other. Local and regional governments, recognizing the potential of these new businesses, launched policy initiatives to help high tech businesses locate in the Pacific Northwest, undertake research, commercialize and market their products, and thrive. Most clean energy businesses are as technology-oriented as their predecessors in the electronics, software, telecommunications, and biotechnology industries.

Global Market, Local Jobs, Rising Profits

The market analysis concluded that:

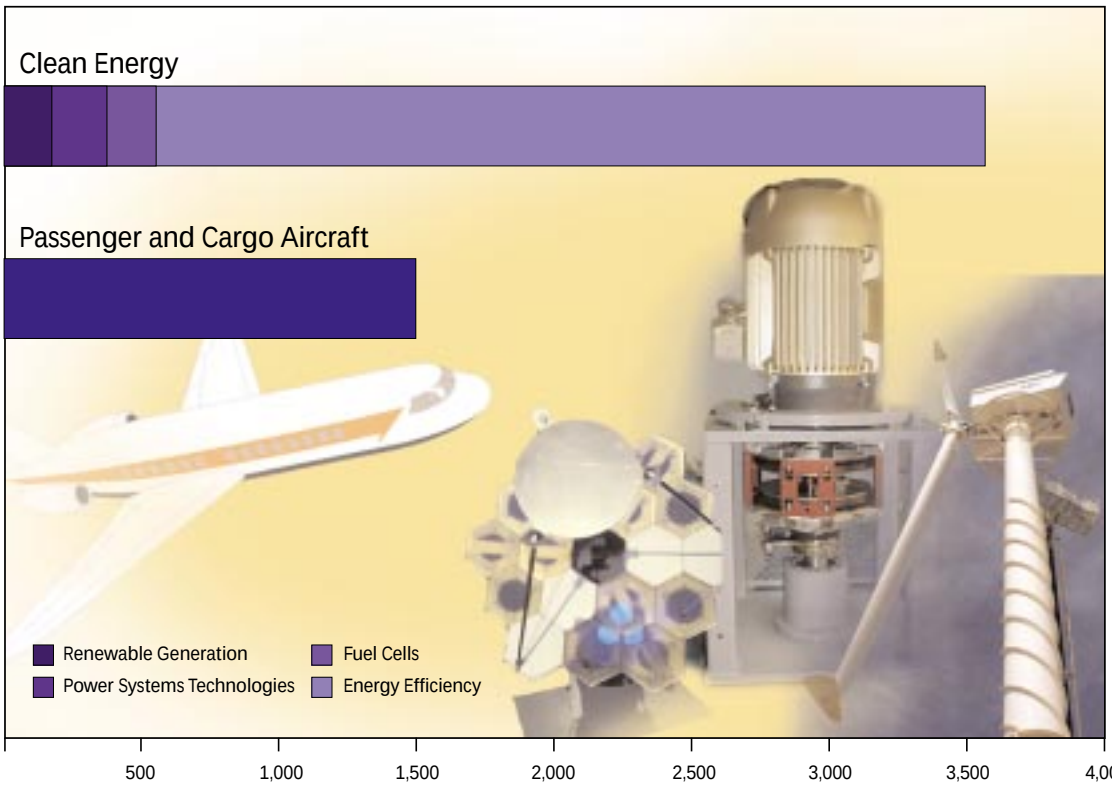
- Worldwide, the market for the seven clean energy technologies examined over the next 20 years is expected to be $180 billion a year, about twice the size of the passenger and cargo aircraft industries.
- This huge global market for clean energy will be much larger still if nations adopt new policies to clean up the air, expand grid access for and purchasing of "green power," and/or combat global warming.
- The Pacific Northwest is already a world leader in fuel cells, and has the ability to develop global leadership in power systems and solar photovoltaics as well. Wind, energy efficiency, and biomass energy sources also offer very substantial economic development potential in the region.
- In Washington, Oregon, and British Columbia, clean energy is currently a $1.4 billion a year industry. Even if government does nothing to support these new businesses, this sector is expected to grow to a total of $2.5 billion a year over the next 20 years and over 12,000 jobs in the region.
- Jobs and dollars could both be much higher with public policies to support Pacific Northwest leadership in this industry. Public policies to help emerging businesses commercialize and market their products could help the region attain a 3.5% share of the global market, resulting in 32,000 jobs over the next 20 years.

What is Clean Energy?

The clean energy sector includes:

- Fuel cells, devices which turn chemical energy directly into electricity and heat, and which may, over the next decade, change the way everything from cars to homes are powered;
- Photovoltaics, sophisticated wafers and films that catch the sun's energy and put it to work;

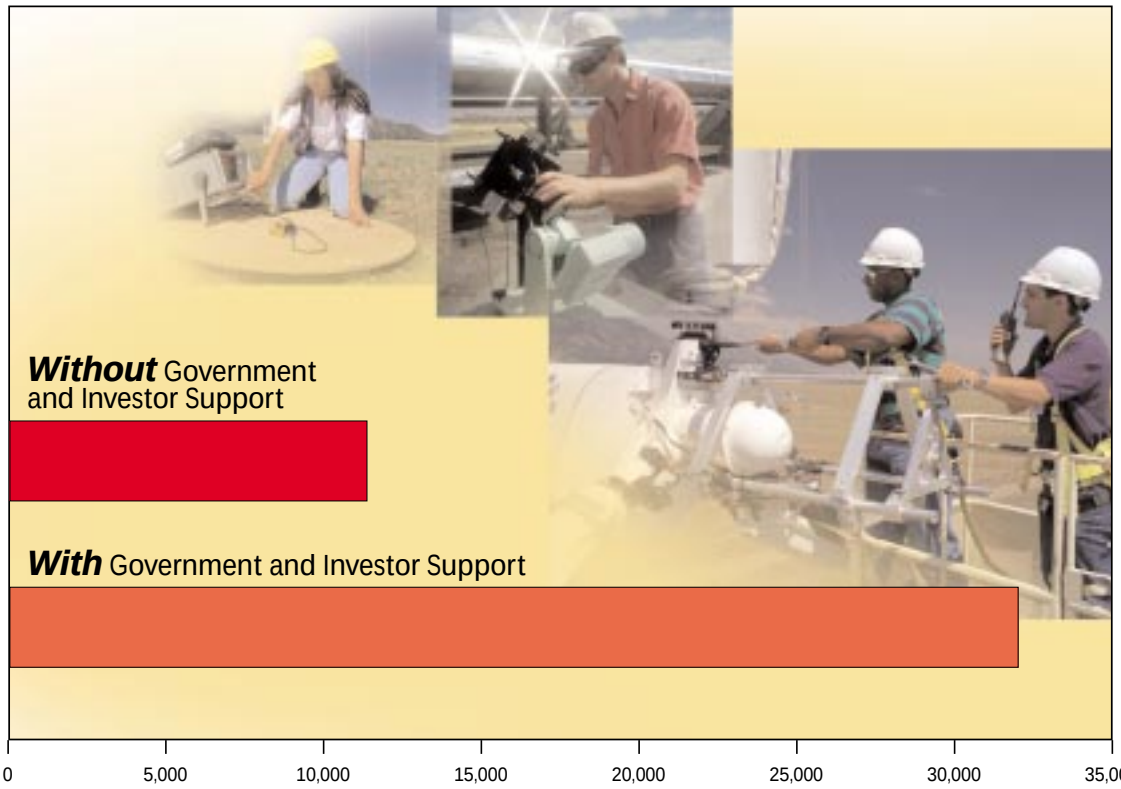
Relative Size of Clean Energy Industry



Global Sales from 2000 to 2020 ($ Billions)

(Sources: Rolls Royce, IEA, ADL, ONL, EREN, EU ATLAS)

New Job Growth Potential in the Clean Energy Industry Over the Next 20 Years



(Sources:Compass Resource Management, Planit Management, EUFORES)

Note: Projection of job growth "Without Government and Investor Support" based on this report's economic projection of $2.5 billion average annual sales for the Pacific Northwest by 2020. Projection of job growth "With Government and Investor Support" based on implementing government policies and encouraging investor support with a goal of the Northwest capturing 3.5 percent of the $180 billion in average annual sales in the global market by 2020 projected by this report. Both sales projections are applied to a factor of 5 jobs/per $1million as derived from the European Forum for Renewable Energy Sources' (EUFORES) 1999 report: "Impact of Renewables on Employment and Growth".

- Advanced power systems that store, transmit, and control energy more effectively and efficiently;
- Wind turbines, geothermal installations, small hydro plants, and biomass fuels; and
- Energy efficiency, the technologies that make traditional power sources more effective and efficient.

Policy Proposals to Harness the Market

British Columbia, Washington, and Oregon are already home to some of the leaders in clean energy, businesses such as Ballard Power Systems, Siemens Solar, and Avista Labs, that are winning national and international acclaim for their work. The region is also home to hundreds of energy efficiency firms and dozens of smaller and newer companies struggling to turn technological innovations into marketable products. Like their predecessors in other high-tech sectors, these businesses will succeed or fail based on how well they make the transition from technology to market. Those that succeed will, of course, provide not just new (or more efficient) energy but new jobs and opportunities for thousands around the region.

The global prospects for a variety of new technologies require the engagement of government leaders, utilities, and investors to make clean energy the next chapter in the region's technology revolution. Government can be particularly helpful in identifying emerging businesses and helping businesses with product development, business planning, and access to venture capital.

Proposals accompanying the market analysis suggest ways to develop the potential in this high-tech clean energy industry, recommending that local and state governments follow similar strategies to those that were used to help develop the high technology sector, including:

- Technology development. Like other high technology ventures, technology-based clean energy businesses need access to high-quality research facilities as well as skilled workers and scientists.

- Commercialization. Clean energy businesses with a new technology must find ways to commercialize that new technology in a marketable way. State or local government might sponsor a business roundtable or help businesses create an association to work on their behalf in networking, seeking venture funds, and lobbying.

- Market development. For clean energy businesses, success in the marketplace with a new product or service often depends on their ability to work with utilities to gain access to power markets.

For a copy of the complete study and a list of clean energy technology experts and businesses in the Northwest, please call Rhys Roth at Climate Solutions 360-352-1763 or visit www.climatesolutions.org.

Part 1.

Market Analysis:

Towards a Globally Competitive Clean Energy Industry in the Northwest

Abstract

This report examines global markets for clean energy and prospects for developing a competitive, export-oriented clean energy industry in the Pacific Northwest. Prospects for establishing leadership in the development, manufacture and distribution of clean energy technologies and related services are explored. Although there are potential synergies with increasing local clean energy supplies, an important objective in its own right, this analysis focuses on the unique opportunities, challenges and benefits associated with building industry leadership along the lines of the Danish wind turbine industry. This analysis was undertaken to inform the preparation of a policy blueprint to stimulate the growth of a regional clean energy industry.

Section 1 of this report summarizes the opportunity for the Pacific Northwest's clean energy sector, and integrates relevant data on key markets and technologies with findings from industry and investment community surveys and interviews.

Section 2 provides an analysis of the global market for clean energy, including key drivers such as global demographics, energy demand, and energy supplies. It examines specific opportunities and barriers in five regional markets, including the Pacific Northwest itself.

Section 3 explores the individual technologies in some depth and draws conclusions about whether the Pacific Northwest can be a global industry leader in these technologies.

The report concludes that the region has the beginnings of an industry cluster based around fuel cell, power system and solar photovoltaic technologies, and the region has a reasonable chance of developing that cluster into a global export industry.

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Building a Globally Competitive Clean Energy Industry in the Pacific Northwest:
an Overview of the Opportunity

Introduction

For many outside the region, the Pacific Northwest[1] is best known for its picturesque coastal mountain environment, affluent and environmentally conscious citizens, world-leading high technology sector, and relatively abundant and cheap supply of hydroelectric energy. Although an important engine in the region's historical development and an ongoing source of low-emission power, the region's supply of hydroelectricity faces growing constraints due to concerns about social and ecological impacts, particularly impacts on fish and wildlife.

Today, the Pacific Northwest is actively pursuing alternative energy sources - wind farms, biofuels, small hydro, fuel cells, and solar cells, among others - that many hope will transform the region's energy landscape, both figuratively and literally. With the days of state-controlled mega-projects behind them, the challenge facing today's leaders is how to leverage the region's technical and entrepreneurial resources to build a world-class clean energy industry – an industry that promises to provide high quality jobs, stimulate economic growth and diversification, and protect the natural environment.

This analysis provides an overview of the global market for clean energy, the current status of clean energy technologies in the Pacific Northwest, and opportunities for the Pacific Northwest to build global industry leadership.

What is Clean Energy?

Dividing energy technologies neatly into categories of "clean" and "conventional" is problematic.

The following technologies are considered "clean" by most analysts: wind energy, solar energy, geothermal energy and appropriately sited small hydroelectric power (typically limited to facilities under 10 MW).

Fuel cells (both stationary power and transportation applications) are also included in many definitions of clean energy, but the degree to which many consider this technology "clean" often depends on the fuel source. Fuels cells powered by hydrogen derived from renewable energy sources are generally considered clean, but fuel cells powered by natural gas or other fossil fuels could, in some circumstances, also represent an improvement over conventional technologies.

Biomass energy is also included in many definitions of clean energy, but again the degree to which many consider biomass technologies "clean" often depends upon the source of biomass. Biomass and biofuels derived from sustainable farming or forestry are typically included in most definitions of clean energy.

There is much less consensus regarding biomass energy derived from municipal waste, although in certain circumstances this could also represent an improvement over conventional waste disposal and energy production practices. In this overview of the clean energy market, the full spectrum of biomass energy is treated as a single clean energy sector, with special cases noted where relevant.

The clean energy sector can also include a variety of ancillary "power system technologies" that improve the efficiency of the entire power system through advanced measurement, controls, storage (e.g. flywheels or batteries) and communication systems.

Technologies and services that enhance the efficiency of energy use complete the definition of the clean energy sector. Energy efficiency comprises a broad range of loosely related products and services, from energy management software and advanced building design to more efficient appliances and building components. Due to the sheer size and diversity of the sector and scope limitations for this study, "energy efficiency" is treated at a fairly high level as a single aggregate industry for the purposes of this market overview.

1 Encompassing British Columbia, Washington State and Oregon.

Building industry leadership vs. local supply

…building industry leadership is not the same as building local clean energy supplies…

This analysis focuses on opportunities for building global industry leadership in the clean energy sector. This means leadership in developing, manufacturing, and distributing clean energy technologies and services, both locally and globally. Although there are potential synergies with increasing local supply of clean energy, an important objective in its own right, there are unique opportunities, challenges and benefits associated with building global industry leadership.

For example, wind energy represents a potentially large and increasingly economic source of new clean energy supply in the region. However, much of the technology is likely to be sourced outside of the region. For example, the contractor for the Vansycle Ridge wind farm in Oregon is Vestas-American Wind Technology, a California-based firm responsible for North American installations of turbines developed by its Danish parent company, Vestas Wind Systems. The project's developer FPL Energy is based in Florida. Local people have helped to install and operate this facility, which is under contract with Portland General Electric. Some of the components were probably manufactured nearby. But much of the investment capital still flows outside the region to purchase equipment developed and manufactured elsewhere.

The Danes, on the other hand, elected to pursue the export market for wind technology and now claim roughly 50% of global market share in the wind turbines, a market worth about $3 billion annually in 1999. Wind turbine manufacturing, maintenance, installation and consultancy services accounts for some 12,000 jobs in Denmark, while component supplies and installation of Danish turbines currently accounts for another 6,000 jobs worldwide. For comparison, about 40,000 people are employed worldwide in wind energy.

While wind and other technologies such as energy efficiency may play a very important role in providing the Pacific Northwest with a sustainable energy supply and increased construction and service jobs, the focus of this analysis is to investigate prospects for the Pacific Northwest to develop global industry leadership in particular technologies or services.[2]

The global opportunity

The clean energy sector is large by any standard. Globally, new investment in the sector is expected to exceed $3.5 trillion between 2000 and 2020, an average of $180 billion per year. This is nearly twice the projected size of the global market over the same period for passenger and cargo aircraft, another substantial industry in which the Northwest already possesses some global leadership (Chart 1).

The majority of the sector's size is attributable to energy efficiency technologies and services. Even after putting this to one side, however, the clean energy sector remains worth over $500 billion in sales from 2000 to 2020.

Fuel cells, power system technologies and energy efficiency are expected to experience the largest absolute growth between 2000 and 2020 (Chart 2). Fuel cells, geothermal power and solar power will likely see large investments in R&D over the same period. Sales of both solar and fuel cell technologies are expected to accelerate beyond 2030.

These projections are based primarily on modelling data from the International Energy Agency (IEA), which uses fairly conservative assumptions regarding government policies to support the deployment of clean energy technologies. Much higher growth rates may occur under more aggressive policies to control greenhouse gas emissions and promote renewable energy. For example, under a more aggressive policy scenario, the share of wind, solar, geothermal, biomass and small hydro in the US and Canada alone could increase five-fold relative to the reference scenario

2 Other industries can also be used to illustrate this point. For example, there is a large potential market for alternative vehicles in the region (e.g., hybrid cars). Greater adoption of alternative vehicles could provide significant local benefits such as improvements in local air quality. The alternative vehicle market may support new jobs associated with selling and servicing vehicles (although some of these jobs may simply replace job losses related to selling and servicing conventional vehicles). In addition, some of the components in these vehicles may have been developed and even manufactured locally. But most of the jobs and investment associated with the market for alternative vehicles will likely occur in established car industry clusters (e.g. the cluster based in the US mid-west).

used in this market analysis - from $22 billion to $120 billion (Chart 3). Total investment in wind, biomass, solar, geothermal and small hydro could increase from $100 billion to $300 billion between 2000 and 2020.

Chart 1: Relative Size of Clean Energy Industry
(Sources: Rolls Royce, IEA, ADL, ONL, EREN, EU ATLAS)

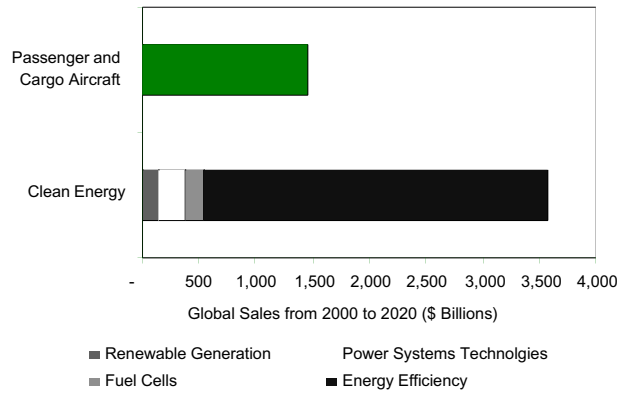


Chart 2: Projected Global Clean Energy, 2000 to 2020
(Sources: IEA, ADL, ONL, EREN, EU ATLAS)

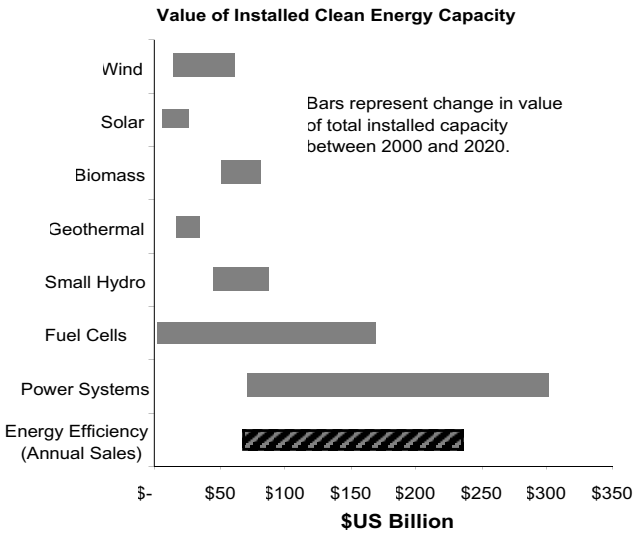
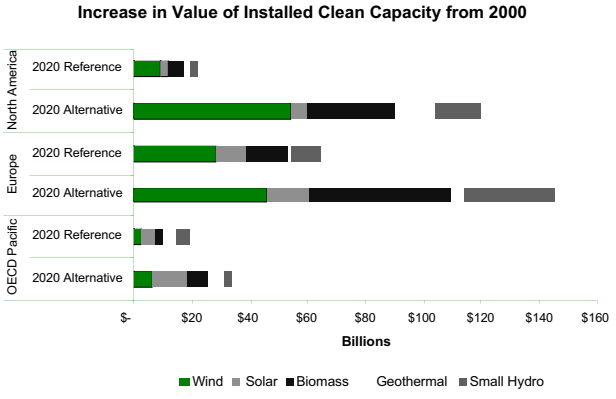


Chart 3: Potential Impact of More Aggressive Policies on the Size of Clean Energy Markets[3]
(Sources: IEA, EU ATLAS)



Geographic markets

Regionally, OECD Europe (see Appendix for regional definitions) is expected to be the largest single market for clean energy technologies and services between 2000 and 2020 (Chart 4). North America is expected to see the second highest annual growth rate. It is expected to invest a total of $113 billion in renewable generation and power system technologies between 2000 and 2020. North America is expected to be a strong market for fuel cells, power systems technologies and wind power in particular. Annual average sales of energy efficiency technologies and services in North America are expected to be about $48 billion.

Under current market conditions and policy assumptions, the Pacific Northwest's average annual investment in clean energy equipment is expected to be about $2.5 billion, a total of $50 billion between 2000 and 2020. About 85% of this will likely be related to energy efficiency technologies and services. Approximately $7.5 billion of investment is expected in renewable generation and power system technologies in the region between 2000 and 2020 (Chart 5).

In addition to local markets in the Pacific Northwest and potential markets in the rest of North America, other regions of potential interest to the Pacific Northwest include Asia, South America and Europe. More detail on regional market potentials can be found in Section 2.

In order to convey the magnitude and nature of specific opportunities, the following summary examines one representative country in each of these regions. Within South America, there are significant short-term opportunities in electricity supply generally and clean energy specifically. Total investment in clean energy sources is expected to reach $64 billion between 2000 and 2020. About 80% of these expenditures will be on energy efficiency technologies and services. Brazil will be a particularly good market for biomass and power system technologies.

3 Potential policies include a Renewable Portfolio Standards (regulated targets) of 8.1% in the US, 10% in Europe, and 6.4% in Asia by 2020. In comparison, current renewable energy content is about 2.5% in the US, 4.5% in Europe, and 2.5% in Asia. IEA has not applied this scenario to the remaining global regions, or to other technologies.

Chart 4: Projected Installed Clean Energy Capacity (Excluding efficiency), 2000 to 2020

(Sources: IEA, ADL, ONL, EREN, EU ATLAS)

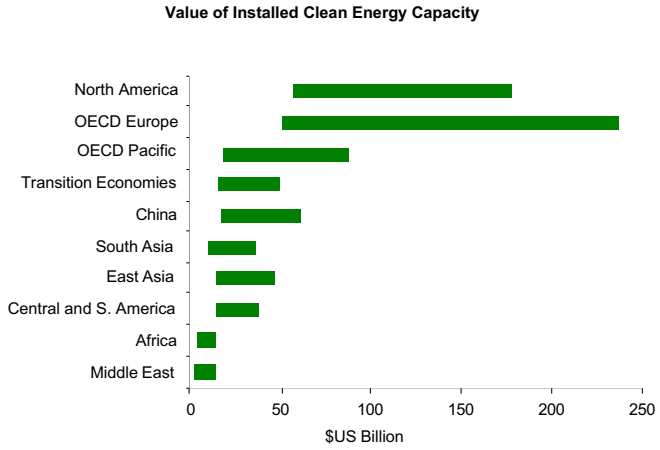
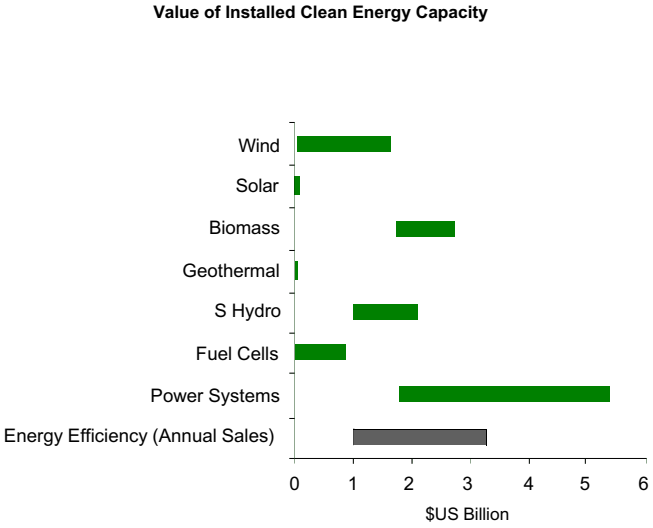


Chart 5: Projected Installed Clean Energy Capacity in the Pacific Northwest

(Sources: IEA, ADL, ONL, EREN, EU ATLAS, EIA)



In Asia, India is also experiencing a severe supply crunch with low system reliability, high power theft, and high prices, partly as a result of historical under-investment. India expects about 10% (30GW) of its generation will come from renewables by 2010. However, the IEA expects the actual figure will be more like 5% (15GW). Even using the more conservative estimate, this translates into a total of $56 billion in clean energy investment between 2000 and 2020. Almost $20 billion will be invested in power system technologies, wind, small hydro and biomass alone. Furthermore, unlike many other regions, there are limited local competitors in supplying technologies and expertise.

In Europe, Germany is expected to invest a total of $320 billion in clean energy technologies between 2000 and 2020. Of this total, about $38 billion will likely be targeted towards power system and energy production technologies. Like much of Europe, there will be significant competition from a number of world-leading clean energy companies based in the region, which have benefited from many years of high domestic energy prices and policies that have boosted the competitiveness of clean energy applications in local markets. However, persistent transmission and generation constraints coupled with favourable clean energy policies will promote rapid growth within these markets.

Pacific Northwest strengths

The current clean energy industry in the Pacific Northwest comprises a diverse and dynamic collection of firms and technologies (Table 1). Based on a survey conducted as part of this study, the majority of local firms were founded by researchers or entrepreneurs that happened to live within the region, rather than attracted to the region based on other location-specific factors such as market access or skilled labour and other inputs. To date, the majority of these firms have focussed almost exclusively on developing local markets.

All of these firms provide a potential source of local clean energy supply and jobs. However, the focus of this study is on identifying strategic opportunities to create a world-class industry cluster[4] capable of attracting significant amounts of local investment and jobs, based not only on deploying technologies from other regions, but developing, manufacturing, and exporting technologies and services.

Specialization is often necessary, at least initially, for developing a sustained competitive advantage in any market. The following seven criteria were used to identify technologies that could potentially

4 A cluster is generally characterized by a critical mass of skills and complementary products and services. Xantrex and Applied Power, for example, have begun to address customer needs for complete power systems by integrating their energy storage technologies with others' intermittent solar photovoltaic generation systems.

form a focussed core for a globally competitive (export-oriented) clean energy cluster in the region:

1. Size, accessibility and growth of key markets
2. Stage of technology development
3. Competitive position of Northwest
4. Economic leverage
5. Synergies with other energy technologies
6. Workforce Synergies
7. Local supply potential

Section 3 provides a complete definition of these criteria, together with a more detailed evaluation of each technology. Based on this analysis, fuel cells, power systems technologies and solar photovoltaics offer the most promising areas for establishing global industry leadership in the Northwest.

Though still a few years away, the global market for fuel cells could be worth more than $170 billion globally between 2000 and 2020. The technology is at an ideal point in its development (i.e., just becoming commercial) and the Pacific Northwest has a dominant global player and a number of strong supporting firms involved in developing fuel reformation and delivery systems, engines, and controls. Successful development of fuel cells could also draw skills and technology to the region that would benefit other clean energy producers.

Technological advances, new system standards, market restructuring, and customer demand will likely converge within the next ten years to open markets for new power system technologies – a market that may be worth more than $ 230 billion between 2000 and 2020. With its current base of technologies and skills, particularly with respect to information technology, the Pacific Northwest could establish global leadership in aspects of this market. This could also complement other energy technologies of interest to the Pacific Northwest.

The Pacific Northwest does not currently have the same level of leadership in solar photovoltaics as it does in fuel cells or power system technologies, but it does have notable pockets of expertise in advanced thin film technologies and several promising early stage companies. Key reasons for including solar photovoltaics as a promising technology to support a local industry cluster include the current stage of development of the technology, the high value-added nature of phototvoltaic development[5], the potential synergies with both power system technologies and fuel cells, and potential synergies with the region's existing hi-tech industry and workforce. Markets will be modest in the near term, but there is little debate that solar photvoltaics will make a major contribution to world energy needs in the long-term. Given the still early stage, the Pacific Northwest has an opportunity to establish itself now as major player in this future market. Total sales of solar photovoltaics between 2000 and 2020 are expected to be about $ 20 billion.

5 This holds true even if some final manufacture occurs closer to customers. The high value R&D and pilot manufacture would remain in the Pacific Northwest. For example, many components for Danish wind turbines are manufactured in other countries and there is significant local employment associated with the actual installation of Danish turbines. However, Denmark, which currently captures 50% of the world market for turbines, still accounts for more than 1/4 of total employment in the industry worldwide.

Table 1: Selected Local Clean Energy Firms

Technology	Representative Companies in the Pacific Northwest	Technology	Representative Companies in the Pacific Northwest
Wind	Global Energy Concepts (WA) Wind Turbine Company (WA)	Small hydro	Canyon Industries (WA) Dependable Turbines Ltd (BC) Hydro West Group (BC) Large civil engineering firms (e.g. Raytheon Infrastructure Inc in WA)
Solar photovoltaic	JX Crystals (Infra-red PV, WA) Schott Applied Power (WA, Parent Co in NY) Siemens Solar (WA manuf for CA-based subsidiary of German co) Xantrex (BC, includes Trace Engineering (WA subsidiary)	Fuel Cells	Avista (WA) Ballard (BC) Cellex (BC) Idatech (OR) Innovatek (WA) Neah Power (WA) NuElement (WA) Questair (BC) Xcellisis (BC)
Biomass	Dynamotive (Fuel Oil - BC) Heuristic Eng (Gasification -BC) Pyro Industries (Pellet stoves, WA) Travis Industries (Fireplace burner systems, WA) Numerous forest products companies	Power systems technologies	Adv. Power Technology (OR) Applied Power (WA) Linesoft (WA) Nxt Phase (BC) PacificCorp (OR) Power Measurement (BC) Tantalus (BC) Xantrex / Trace (BC/WA)
Geothermal	Crew Development Corp (BC) (mining company with potential interest in developing a BC-based power facility)	Energy efficiency technologies / services	Capstone Manufacturing (WA) Columbia Lighting (WA) Energy Saving Products (WA) Portland Energy Conservation (OR) Ledalite Architectural Products (BC)

Barriers to developing a local industry cluster

Although local supply opportunities are not necessarily required to develop a local industry, in practice such opportunities can help stimulate the development of a globally competitive industry.[6] Not surprisingly, in a survey conducted as part of this study, many local firms identified local market barriers, including lack of market access and a truly level playing field, as the most significant barriers to developing global leadership in the clean energy industry (Chart 6). In addition to the lack of local markets, potential investors also identified weaknesses in business plans and critical marketing skills as potential barriers to raising financing for the industry. These barriers are described further below (Chart 7).

Grid and market access policies / practices

Among the firms surveyed for this study, many identified the lack of timely, transparent and straightforward procedures for accessing transmission and distribution grids and energy markets as a major barrier to growth of the industry. With respect to grid access, some specific barriers include a lack of interconnection standards (particularly at the distribution level), a lack of efficient transmission tariffs, and delays in approval processes. For example, one developer commented that it takes 9-12 months for the local utility to decide what space is available on a given transmission line, and then another 12 months to determine the impact of the new resources on system stability. Even where grid access exists, many developers noted additional market barriers to selling their output, whether under long-term contracts or spot sales. Similarly, depending

6 For example, the rush to wind energy in California during the early 1980s was a major stimulus for the early growth of the Danish wind turbine industry.

upon the interconnection requirements of the local utility and policies regarding the allocation of grid-side costs and benefits, producers can face a net price that is substantially less than market prices for energy.

Lack of a level playing field

Clean energy technologies offer a number of potential social and environmental benefits over large, centralized fossil fuel technologies (e.g., low footprint impact, negligible emissions). Many industry participants noted that capturing these benefits would help improve the competitiveness of clean energy technologies.

Lack of financing / investor interest

With respect to capital for research and development, certain high-profile technologies (particularly fuel cells) are receiving large support from agencies and corporations. However, virtually all companies noted a lack of venture capital as an important barrier to sustained growth. Based on a survey of the investor community, three factors may contribute to this apparent lack of investor interest in the clean energy industry.

First, many investors feel that the clean energy industry is not competitive and entirely dependent on the non-market oriented support of governments and utilities. Many investors are weary of significant reliance on policy or financial support as a form of competitive advantage since these could be easily reversed.[7]

Second, many investors do not perceive of clean energy as "high-tech". Clean energy is often associated with more negative impressions of the energy industry which many feel is highly regulated, slow moving, high risk, and yields only a low return on investment.

Third, many investors feel that most of these firms, particularly small ones, are too focused on technology and lack a real understanding of customer needs and marketable products. Many firms may need to become more business oriented to attract venture capital. This could include hiring managers with more business experience and preparing much stronger business cases. "Lots of entrepreneurs are not aware of what it takes to attract venture capital," observed one investor.

In particular, investors want to see an understanding and analysis that demonstrates a significant market for a technology or product.

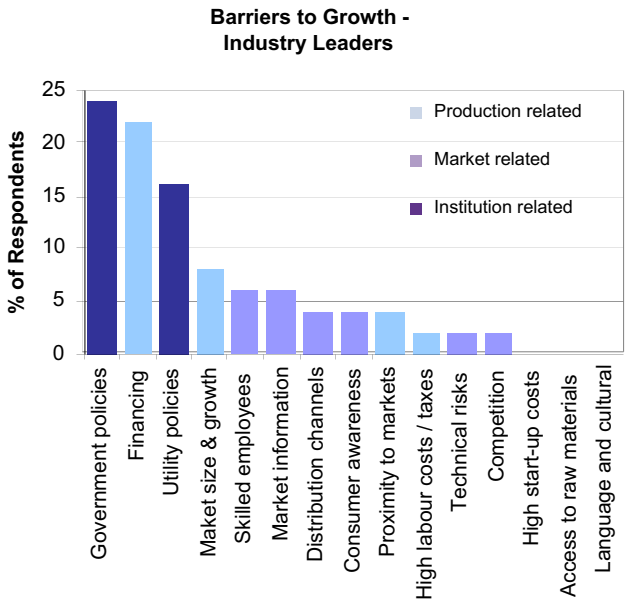
Utility culture and incentives

Some industry participants argue that utility culture and the lack of incentives for regulated utilities to invest in new technologies that reduce costs is a general barrier to the uptake of new technologies in the energy industry.

Skilled workers

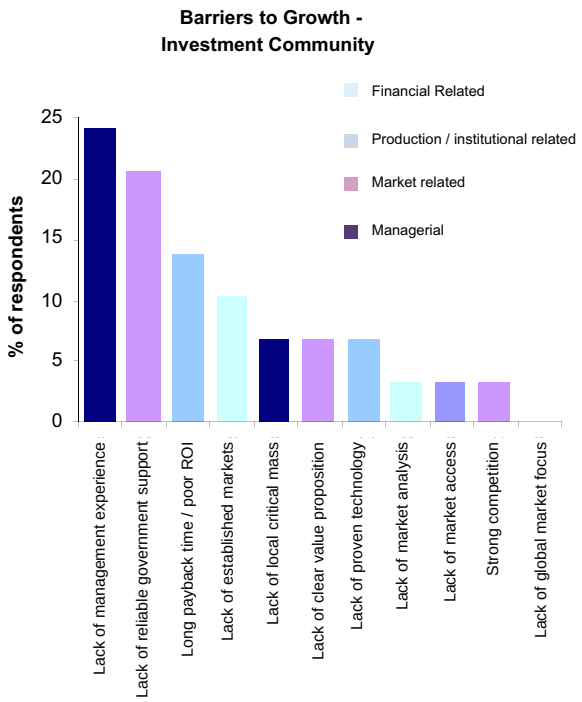
According to those firms surveyed, the supply of skilled workers is not currently a critical limiting factor in development of the industry. However, firms requiring specialized skill sets are anxious about the future availability of skilled workers. Should a globally competitive clean energy industry begin to emerge, it is possible that demand for electrical, mechanical, process and software engineers will outstrip local supply.

Chart 6: Perceived Barriers: Industry (n=25)



7 For example, public incentives for wind energy development was responsible for a significant "wind rush" in California during the early 1980s. Danish wind turbine manufacturers, which had an early lead in the technology, benefited greatly from the new and large market. However, when the California wind programme ended in the mid-1980's, a large number of Danish manufacturers went bankrupt. This was followed by a long period of industry consolidation and attempts to diversify into other geographic markets.

Chart 7: Perceived Barriers: Investment Community (n=11)



Summary of key findings

1. The global market for clean energy technologies and services is conservatively expected to exceed $3.5 trillion between 2000 and 2020. The majority of this market will be in energy efficiency technologies and related services. The market for power system and clean energy production technologies alone will exceed $500 billion over this period. Proactive global and regional energy policies could push the size of these markets even higher.

2. Based on global market opportunities and local strengths, the Pacific Northwest has the greatest chance of building a global export industry centred around fuel cells, power systems technologies, and photovoltaics.

3 Other technologies such as wind, biomass, small hydro and efficiency will likely play a significant role in meeting the region's energy demand and generating important installation and service jobs, but many of the underlying technologies will likely be sourced outside the region.

4. Potential markets for the region's clean energy cluster are large, accessible regions that have a combination of high transmission or generation constraints, and favourable public policies towards clean energy (e.g., carbon and other emission taxes, renewable portfolio standards, and financial incentives). Besides local markets in the Pacific Northwest, other promising target markets existing in the rest of North America, South Asia, Europe and South America.

5. Some potential barriers to the development of a local industry cluster include:
   - lack of access to transmission/distribution grids and energy markets;
   - lack of a level playing field among energy technologies (e.g., non-priced costs and benefits of different technologies);
   - lack of financing, which may be the result of investor concerns over reliance on government policy/support, negative investor perceptions of the energy industry generally, and concerns over the lack of customer focus and defensible business plans within technology-oriented firms;
   - the lack of a culture or market incentives within utilities to adopt new technologies that may reduce the cost of service; and
   - potential future shortages in skilled workers if the industry really takes off.

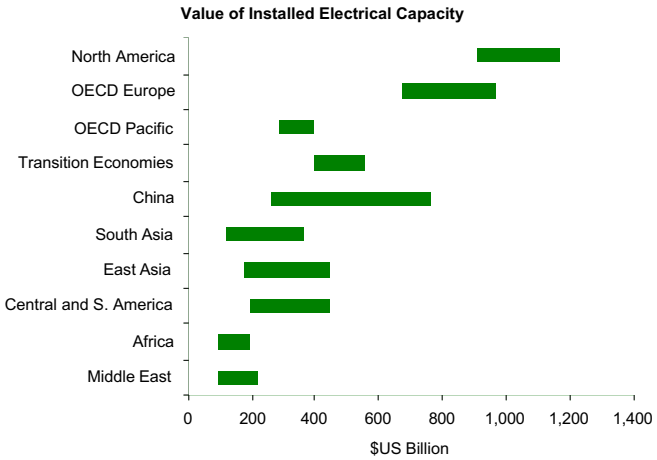
Detailed Analysis of Regional Clean Energy Markets

Global overview

Global primary energy demand[8] is expected to increase 50% by 2020 to about 15 billion tonnes of oil equivalent. The market value of traded primary fuels is currently estimated at about $17 trillion globally, and is expected to rise to $27 trillion by 2020. The largest relative increases in energy demand will occur in developing and transition countries, largely due to high rates of population and economic growth. Nonetheless, North America and Europe will remain the largest energy users over this period – both in absolute and per capita terms. In fact, North America consumes more primary energy now than any other region will for at least twenty years.

The International Energy Agency (IEA) anticipates substantial investments in new generating capacity in coming years, with the largest absolute increases in developing regions (Chart 8). Approximately 2,300 GW of new capacity will be installed worldwide, about 2.5 times the current installed capacity of North America. Much of this new plant is destined for China with North America, Western Europe, India, East Asia and Central and South America each receiving approximately even shares. Along with this new generating capacity will come associated needs for power system technologies to help reduce system losses, enhance system reliability, and improve power quality.

Chart 8: Global Electrical Capacity, 2000 to 2020
(Source: IEA, EIA)



A Note on Market Forecasts

Estimates of the size of clean energy markets in this report are based largely on data from the International Energy Agency (IEA), widely recognized as one of the world's leading providers of global energy sector statistics and energy forecasting. Where possible, IEA data is supplemented with information from other sources, and informed assumptions are made throughout (see Appendix).

Inevitably, there are often discrepancies between the different forecasts from various agencies. For example, wind power is currently experiencing rapid growth around the world – for example, in Germany alone there has been a 50% increase in the installed capacity of wind energy over for the past two years. The US Department of Energy believes that such growth can be sustained in the US, and has forecast target of 80GW of installed wind power in the country by 2020, based on a current installed base of 2.5 GW. In contrast, the IEA predicts an installed capacity of only 12 GW, and a total installed capacity worldwide of under 65 GW by 2020.

Given reliance on IEA data, the estimates in this report may appear less optimistic than forecasts prepared by other analysts or industry associations. However, this approach is consistent with the preferences of the investment community, which would usually prefer to err on the side of a cautious market forecast.

The coming twenty years will see considerable growth in electricity generated from renewable resources in most regions (Chart 9). Europe is expected to over-take North America in terms of installed renewable generating capacity. The largest growth will likely occur within the energy efficiency, power systems and fuel cell sub-sectors (Chart 10).

Although the developing world consumes the majority of the world's current renewable energy production, most of this energy is used to produce low-grade heat. Only a small portion is used to generate electricity. And despite the high rates of growth in overall energy demand and installed generating capacity in develop-ing and transition economies, there will be relatively

8 Includes non-traded renewable energy (i.e. sticks, animal waste etc), which comprises a large fraction of energy use in many developing countries.

less growth in the installed capacity of clean energy within these regions. One reason for this may be the relatively modest increase in the ability to pay of consumers in developing and transition economies (measured by per capita income) through 2020 (Chart 11).

Much of the growth in clean energy within developing countries will likely come in the form of local industries producing cheaper, less advanced versions of western technologies - from crude wind-powered water pumps to basic micro or mini-hydro systems. Except for small niches, these markets will not be very attractive for firms in the Pacific Northwest. In the remainder of this analysis, we focus on the most promising markets for firms and technologies for the Pacific Northwest, including local markets in the Northwest, markets in the rest of North America and markets in Europe, South America, and South Asia.

Chart 9: Global Clean Energy 2000 to 2020 (excluding energy efficiency)

(Sources: IEA, ADL, ONL, EU ATLAS, EIA)

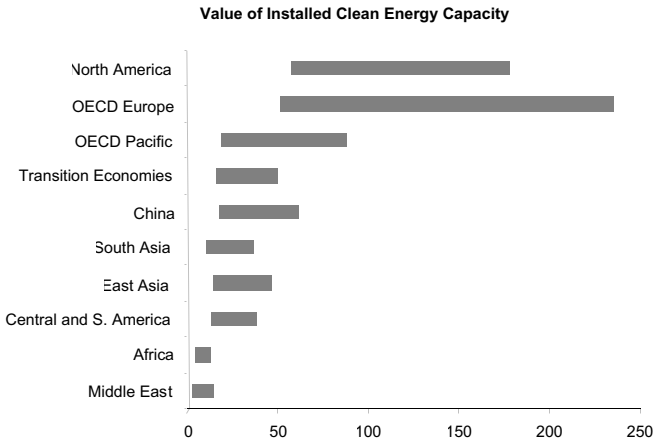


Chart 10: Global Use by Technology 2000 to 2020

(Sources: IEA, ADL, ONL, EREN, EU ATLAS, EIA)

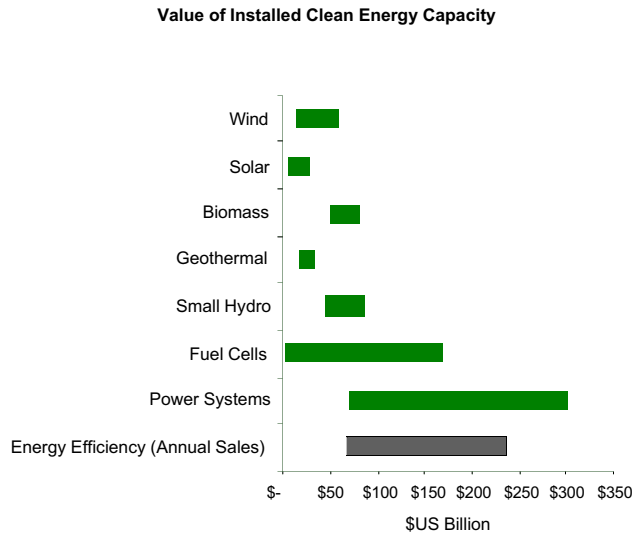
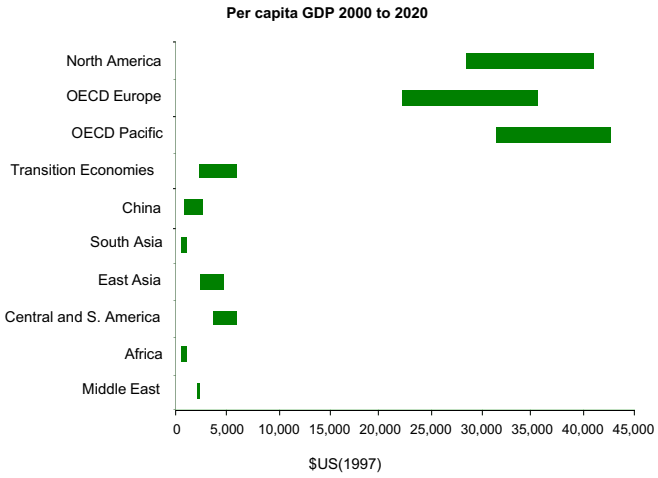


Chart 11: Regional Ability to Pay

(Sources: US Census Bureau, IEA, EIA)



Spotlight on regions of interest to the Pacific Northwest

To help illustrate some of the markets open to the Pacific Northwest clean energy companies, and to highlight disparate market features that may face potential exporters, a number of countries or sub-regions likely to be of potential interest to local firms have been selected for more detailed examination.

Chart 12: Local Firms' Geographic Focus

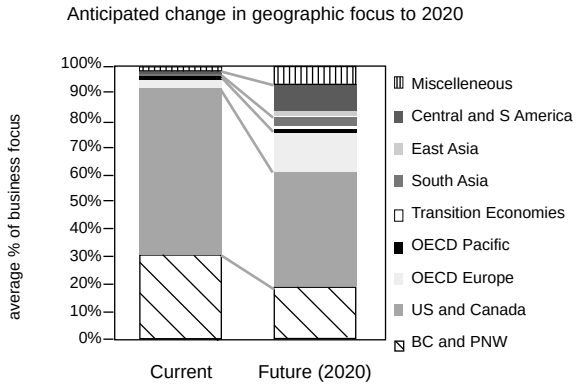


Chart 12 shows how participants of an industry survey see their target markets developing into the future. While the local market and the rest of North America will likely account for the majority of business for some time, there is broad recognition that international markets will play an increasingly important role in the development of the region's industry.

Overseas markets are anticipated to increase in importance from less than 10% to over one third, with BC and Pacific Northwest market itself falls from one

third to one fifth of focus. Among the major drivers for this foreseen shift in focus are the low prices on offer for electricity in North America (that serve to undermine the competitiveness of clean energy versus conventional energy), lack of political support for the clean energy industry, and strong competition among domestic and foreign firms to supply local requirements.

One perhaps surprising feature of this chart is the relative lack of demonstrated interest specifically in Pacific Rim markets. Further research confirms that clean energy markets such as Malaysia, Indonesia and Philippines are likely to remain relatively small and/or relatively inaccessible (as is the case in China, Japan and Indonesia, for example). This is not to say that many Pacific Northwest companies will not carve niches in these markets; rather it suggests that the potential for these markets to help fuel major clean energy industry growth in the Pacific Northwest is perhaps more limited than in others.

The Pacific Northwest clean energy industry collectively sees OECD Europe as the most important international market for its products in the future. Again, this perception aligns well with research that shows that the European market as a whole will become the major forging ground for clean energy technologies for at least the next twenty years. To explore the market opportunities for Pacific Northwest firms associated with this market, focus is given specifically to its largest sub-section, Germany. Germany leads – and will continue to lead – European development of a wide range of clean energy technologies, both in terms of industry development and as a supply environment for clean energy itself. Unlike France, the country's energy sector is relatively open to private investment and is unencumbered by a legacy of nuclear oversupply. Germany has shown substantially greater leadership in fostering and promoting clean energy than the UK or Italy, Europe's other two major economies. Nevertheless, Germany is itself in a state of considerable general oversupply and the Pacific Northwest has no inherent competitive advantage in exploring the country's supply market, so clean energy projects will need to fit a specific local need.

Two other large international markets with open power sectors and declared interests in developing clean energy include India and Brazil. The Pacific Northwest, although not strongly advantaged by institutional or cultural links to these countries, is, however in a strong competitive position relative to many European areas. Both countries have an energy supply scene familiar to Pacific Northwest firms, with large hydropower and biomass sectors, and substantial shortages of supply capacity. Large economies, both countries have the potential to develop sizeable clean energy markets. Crucially, although relatively poor, India and Brazil have relatively high prices for electricity and have renewable generation forecasts substantial enough to ensure their relevance to western energy companies.

Of particular interest in India is the poor condition of the country's transmission network and the attempts underway to improve matters. India is determinedly wooing foreign technology companies and investors. The Indian public's typically strong environmental ethic and desire for security of energy supply also bode well for western clean energy companies. However, India's activist public opinion is often at odds with state and federal government privatization policies, which may in itself constitute a significant barrier to further foreign investment in the country's energy sector.

Brazil is facing imminent power rationing, which has, according to one source, "replaced corruption scandals and financial contagion as the country's top problem". Much of the country's population is without electricity supply of any kind, electricity sector privatization having prevented the expansion of a national grid to the country's interior. Uneconomic diesel-powered minigrids are the workhorses of much of the Brazilian power sector. With a relatively high price of electricity, the potential for clean energy solutions is significant – and recognized by the government as being so.

In the remainder of this section, therefore, some of the issues and opportunities that Pacific Northwest companies will encounter in five separate regions are examined: the Pacific Northwest; the Rest of North America; India; Brazil and Germany.

Quantifying the size of these markets in terms of the amount of hard currency that may be available to pay for Pacific Northwest technologies and services, should help companies begin to judge for themselves what the high-level opportunities and risks are in each region.

Pacific Northwest

Home ground is the default starting point for many companies. But the often-tough circumstances local firms face in their own backyard may help develop strong companies capable of competing well elsewhere when the best locations have been developed.

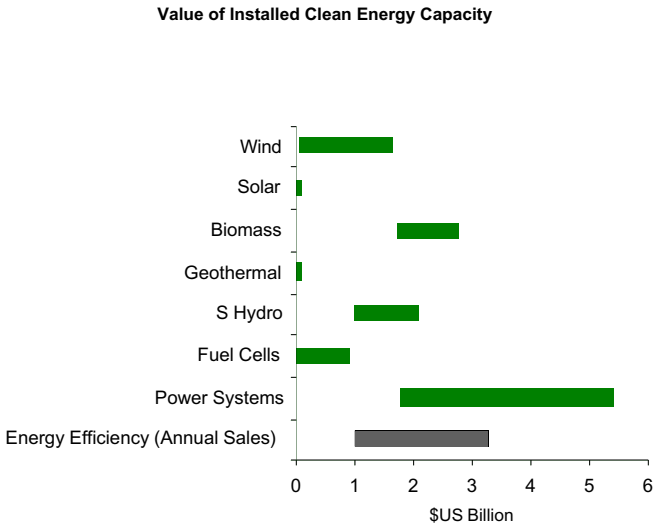
British Columbia, Washington and Oregon have often-distinct issues, institutions and policy frameworks. However, low electricity prices are one major feature that unites the region. Low prices translate to low revenues for clean power producers, and long payback periods for energy efficiency and energy service companies.

Market size and potential

Chart 13 shows an estimate of the total value invested in Pacific Northwest clean energy technologies by 2020.

Chart 13: Clean Energy in the Pacific Northwest, 2000 to 2020

(Sources: IEA, ADL, ONL, EREN, EU ATLAS, EIA, BPA)



At the time of writing, the Pacific Northwest has 25MW of installed wind capacity, at the Vansycle Ridge Plant in Oregon. Firm plans are on the board for a number of projects that will soon see 215MW installed in Washington and a further 125MW in Oregon. BC currently has no firm plans for wind plants, though a number of sites are being monitored by BC Hydro.

By 2020, estimates put the total invested capital in wind at around $1.6 billion, or an average annual investment of $80 million per year. This figure could be higher if the evaluation of bids from BPA's 'request for proposals' (which received bids totalling 2.6GW) shows that a large portion of this capacity is in Washington and Oregon. However, at the time of writing the total underlying capacity (after adjusting for multiple bids on a single site) and the actual feasibility of the bids is unconfirmed.

In order to sustain the planned pace of wind development, the region will need to significantly increase access and capacity at the transmission and distribution level. The region may even need to look for ways to bring loads (e.g. server farms) closer to generation rather than the other way around. BC's lack of developed wind capacity to date speaks in part to the geographical difficulties involved in bringing wind power to urban centres. But even if policy and physical barriers are removed, the fact remains that region is not endowed with remarkable resource potential: according to a 1991 assessment of available windy land for example, the states of Washington and Oregon rank only 23rd and 24th in the US. On the other hand, the presence of large hydro resources does offer the region some advantages in terms of compensating for the intermittent nature of wind power.

For small hydro, although deployment will continue to grow strongly for some time in BC, many of the best small hydro locations are occupied in Washington and Oregon.

Locations suitable for large-scale biomass power rarely coincide with urban centres; extensive new development may, therefore, involve considerable transmission losses, or may be remain restricted to smaller scale applications. British Columbia, Washington and

Oregon have around 600 MW, 400MW and 200MW of installed biomass power respectively, mostly used exclusively by their respective pulp and paper sectors, though this includes some municipal waste incineration, a controversial practice.

Although several US states bordering Washington and Oregon have significant potential for geothermal power, only one site, in BC, is currently under serious consideration. It does not appear that any of these three areas is likely to develop substantial geothermal power in the foreseeable future.

Of the clean energy generating technologies, wind, biomass and small hydro will tend to dominate the Pacific Northwest domestic supply market. Solar photovoltaic will make a relatively minor contribution: around $100 million total invested by 2020. Fuel cells will grow to almost $900 million by 2020, spread across the transportation and stationary power markets. Power systems technologies, however, will pass a $5 billion invested total by 2020.

The development of this supply region will depend strongly on the policies of agencies or utilities such as the federal BPA and PGE, which have helped support the growth of wind in the region against prevailing market drivers, or BC Hydro, which has decided to commit 10% of load growth to "green" energy sources.

As with all regions, the energy efficiency market dwarfs the other elements of the sector considerably: around $40 billion worth of sales in energy efficiency products and services is available between now and 2020 in the region.

Market background

British Columbia's electricity supply scene is dominated by BC Hydro, an integrated utility company owned by the Crown (province) that supplies over 90% of the population; and West Kootenay Power, a US-owned company with operations in the south east of the province. Through the British Columbia Power Export Corporation (POWEREX), BC Hydro has FERC authorization to compete in the US market. However, although open access to the wholesale transmission system was established in 1996, clean energy IPPs continue to express frustration at the opportunities to locate in the province.

In Washington, Puget Sound Energy, Seattle City Light, PUD No 1 of Snohomish County, Bonneville Power Admin and Avista Corporation together account for around two thirds of utility power sales. In Oregon, Portland General Electric, PacifiCorp, the City of Eugene and Central Lincoln People's Utility account for 84% of utility power sales. The California brownouts have highlighted and exacerbated similar shortages in both Washington and Oregon, which historically imported power from their neighbour to the south.

In Washington, the Utilities and Transportation Commission recently announced a settlement that would allow the Puget Sound Energy's six largest customers to buy power from other sources. In Oregon, the Public Utilities Commission has passed a first set of rules regarding restructuring that will allow some large commercial and industrial customers to choose alternative suppliers. However, the House is still debating the bill and the outcome is uncertain. Washington and Oregon have both passed net-metering laws allowing generation at customer sites.

Conclusion

The Pacific Northwest has a wide variety of clean energy supply opportunities: forecasts show that approximately $1 billion will be invested over the next twenty years in each of biomass, small hydro and fuel cell generation technologies, with a $1.6 billion total investment in wind power over the same period. Power systems technologies are likely to attract roughly $3 billion of infrastructure investment over that time, with the much larger energy efficiency sector bringing in more than $2 billion in annual sales for the next two decades.

However, for some of these technologies (particularly wind, small hydro and biomass power) the low-hanging fruit of clean supply sites may become scarce before too long, providing a timely incentive for many to look to markets beyond home ground.

The rest of North America

One of the world's largest, most accessible and wealthiest energy markets is on the Pacific Northwest's doorstep. However, so is one of the world's largest collections of clean energy competitors.

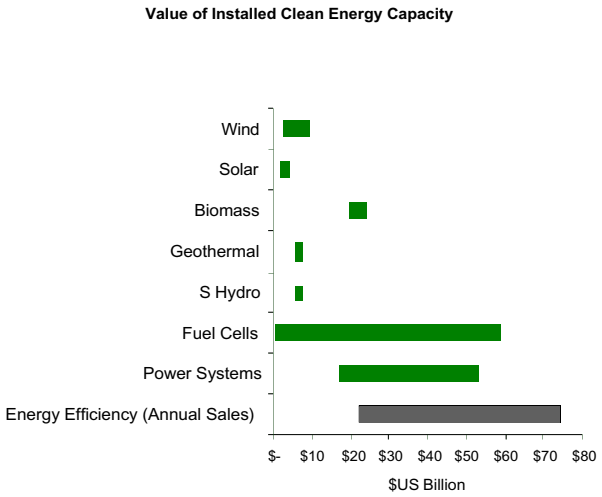
It is difficult to overstate the relative size of the North American energy market. The US alone consumes more than a quarter of the world's primary energy, and Canada is one of the world's leading energy consumers on a per capita basis.

Market size and potential

The 'rest of North America' market shows good potential, again particularly for fuel cells and power system technologies. The enormous energy efficiency sector will rack up a total approaching $1,000 billion by 2020. Biomass will be the dominant clean generating technology, though wind and solar power will make large relative gains.

Chart 14: Clean Energy in the Rest of North America, 2000 to 2020

(Sources: IEA, ADL, ONL, EREN, EU ATLAS, EIA)



Market Background

The North American market has many attractive features for Pacific Northwest companies, of which size, proximity, wealth and cultural factors emerge as key.

The electricity market in both countries is highly regional, with state or provincial commissions regulating the activities of a wide variety of public and privately owned integrated utilities, independent power providers, municipal co-operatives and other organizational structures. The US has a number of federally owned utilities that act as primary producers and wholesalers.

North American opportunities for Pacific Northwest clean energy firms therefore vary considerably depending on location. Generally speaking, the region's companies should first focus on areas with a combination of high generation or transmission constraints, good access to the markets (e.g. eastern states) as well as regions with stringent air quality regulations and good local resource potential (e.g. California).

By international standards, a major weakness of the North American market as a whole is the low average price for electricity. For companies from the Pacific Northwest, however, most North American markets offer more attractive prices than home ground. Also, many states in the US have established renewable portfolio standards, which require a specific percentage of clean energy in electricity companies' supply portfolios. The near term future of clean energy in North America may indeed depend on such an approach from state or provincial legislators. By design, RPSs do not discourage competition in the fraction of the market set aside by state law. Domestic and European competition throughout North American clean energy markets is unsurprisingly strong, and, as mentioned above, will be a major factor in prompting Pacific Northwest companies to consider wider horizons.

India

The world's largest democracy may be on the verge of offering more adventurous elements of the Pacific Northwest's clean energy sector some intriguing opportunities – though substantial institutional risks will remain.

India is well known as one of the world's largest users of both conventional and non-conventional renewable energy. It is equally unfortunately renowned as one of the world's poorest countries, with a per capita GDP only 6% of that of the US[9]. With a correspond-

9 In purchasing power parity.

ingly low ability to pay for western products or services, Pacific Northwest companies may well wonder whether they may have a role to play in the development of clean energy in the subcontinent.

At an estimated $2.8 billion annual average investment over the next 20 years, India's clean energy market is slightly larger than the Pacific Northwest's. Much of this investment will be met by indigenous, low-tech clean energy solutions such as micro-hydro. Discouragingly for Pacific Northwest firms, the country is developing considerable high-tech capability too; solar photovoltaic cells and photovoltaic module manufacturing have grown steadily over recent years.

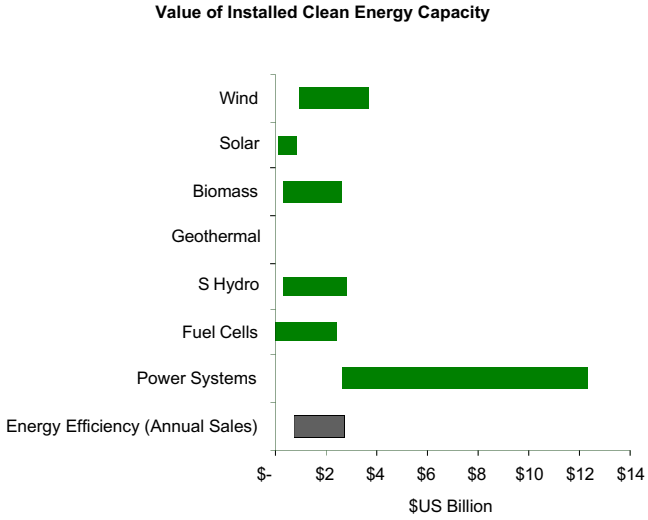
Nevertheless, Pacific Northwest firms expressed some interest in the South Asian market through the survey. The Indian clean energy sector does have a number of encouraging features, including a relatively high average price for electricity ($59/MWh in 1999), a considerable shortage of generating capacity, unreliable transmission and distribution infrastructure, and a proactive government approach both to clean electricity generation and to foreign investment in clean energy technologies.

Market size and potential

Although similar in overall size to the Pacific Northwest's, India's clean energy market has a substantially different breakdown. Energy efficiency sales are relatively lower, and the power systems technology and renewable generation market will be worth an average of $1 billion between now and 2020.

The short and long term potential for the growth of both conventional and clean electricity technologies in India is enormous. According to the Tata Energy Research Institute, the country as a whole has around an 11.5% energy shortage, with peak shortfalls of around 18%; 20% of the population still does not even have access to electricity.

Chart 15: Clean Energy in India, 2000 to 2020
(Sources: IEA, ADL, ONL, EREN, EU ATLAS, EIA, TERI)



Market background

Unlike the most other segments of its energy sector, Indian federal involvement in both electricity generation and clean energy supply is relatively minor, with federal government taking a leading role in the state transmission network and high level policies such as the recently-proposed renewable portfolio standard (10% - 30GW - by 2012). The balance of incentives and barriers to foreign clean energy investment is therefore regionally variable. Among the higher-level federal power supply regulations developed to encourage foreign participation are liberal policies towards foreign ownership of projects, the provision of loans for capital expenses and tax exemptions.

Although the price of electricity is nominally high, many pay nothing at all for their power. Theft of electricity in many regions of India has reached epic proportions, and there are inadequate metering systems, billing procedures and revenue collection (themselves possible opportunities for Pacific Northwest companies). Transmission losses average 18%, rising to nearly 40% in some regions. Private sector funds are being courted to provide the required investment, both through state reforms and through the country's national transmission company, Powergrid.

Most states are making considerable investments in new generation capacity, and the federal government, through the MNES (Ministry of Non-conventional

Energy Sources) and IREDA (Indian Renewable Energy Development Agency, a 'public sector company of the Ministry'), is similarly looking to attract both domestic and foreign capital investment. For example, the Ministry recently issued a set of guidelines to all states suggesting the development of general policies for purchase, wheeling and banking of electrical energy generated from all renewable energy sources. Fourteen states have so far published details of their policies, which are published on the Ministry's website.

According to the MNES, India currently has around 1.6 GW of installed renewable generating capacity (though the IEA put this figure at 930 MW in 1998). The vast majority of this is in the form of wind power, for which India is the fifth largest supply country in the world. Biomass power and small hydro accounts for a further 16% and 13% of this total respectively; there is around 40 MW of installed photovoltaic power, approximately half of that installed in the US.

Aside from the country's overall low ability to pay for western products and services, there remain a number of substantial barriers that Pacific Northwest companies will face in doing business in India.

Many of these barriers are a result of the general institutional framework of the country. Corruption, for example, remains a major business barrier, and the US State Department notes that the government procurement system has been particularly subjected to allegations of corruption in the telecommunications and power sectors.

Pacific Northwest firms will also need to find local partners if they are to take advantage of many of the incentives offered to support clean energy in the country. While still relatively open to foreign companies, a primary state objective will naturally be to keep as much hard currency in the country as possible. Enron's difficulties with the government Maharashtra also highlights the discrepancies that can arise between policy and the situation on the ground – with many socialist and communist enclaves, market reforms are likely to meet with considerable local disdain[10]. The degree to which such attitudes will affect smaller scale, clean technology projects remains to be seen.

Conclusion

Although India's need for renewable generation looks set to grow impressively, the technologies already established in the country do not play particularly well to Pacific Northwest strengths. The Pacific Northwest, as discussed elsewhere in this analysis, has no established wind industry, and its small/micro hydro sector will be pushed to compete with local companies on anything other than advanced components or control technologies.

More interesting from the Pacific Northwest's perspective would be the potential for power system technologies and services, both those that may help the country's beleaguered transmission and distribution grid, as well as those that may support the application of intermittent renewable energy sources in rural applications.

Longer term, fuel cells and solar may also ultimately play a significant role in the country's energy sector. India has an enormous potential for the inexpensive production of biomass-derived fuels that may be employed as the raw material for fuel cell generation on a variety of scales.

Brazil

Like India, Brazil is typified as having a large clean energy market with limited ability to pay for Pacific Northwest products and services. But with power supply now a full-blown national crisis, electricity has become a prized commodity – potentially leading to real opportunities for Pacific Northwest firms.

Brazil is by far the largest energy market in South America, and as such – current trade negotiations considered – may emerge as a major arena in which North American clean energy companies have an inherent advantage over their typically highly competitive European and Japanese counterparts.

Brazil has a power landscape that is familiar to Pacific Northwest residents, with large-scale hydroelectric facilities dominating domestic supply. However, in Brazil as in the Pacific Northwest, the share of large hydro will steadily decline as the government seeks to increase diversity of supply and avoid the environ-

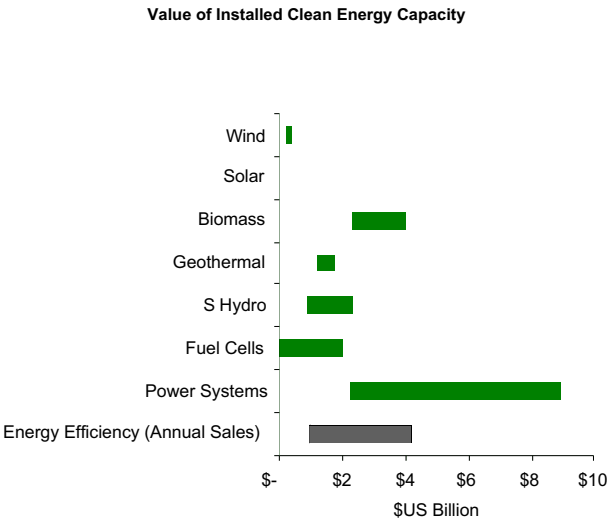
10 Since 1992, Enron's attempts to co-develop a 2.2 GW natural gas power plant at Dabhol has met with a series of disputes with local authorities and protests by local people.

mental impacts now recognized to be associated with large hydroelectric facilities. Of notable concern is the greenhouse gas impact of such projects in tropical climates; according to the US EIA, Brazil has been at the forefront of global discussions on climate change given the potential of its rainforests for carbon dioxide sequestration, and remains sensitive to the issue.

Market size and potential

Chart 16: Clean Energy in Brazil, 2000 to 2020

(Sources: IEA, ADL, ONL, EREN, EU ATLAS, EIA)



Brazil's biomass and small hydro industries are already quite established, and will likely see a further $3 billion investment before 2020. IEA predicts a relatively low uptake of wind and solar power in South America as a whole.

In surveys, Central and South America ranked as the fourth most likely important region to the Pacific Northwest industry by 2020.

Market background

Brazilian power sector privatization is well underway. Private investors own 26% of generating capacity and 63% of the distribution network. Recent Brazilian legislation actually requires tender processes for any new transmission line above 230 kV as part of the Brazilian basic network. However, perhaps as a result of privatization, planned national grid expansion into the country's interior has not taken place, and interior power continues to rely on ostensibly temporary, uneconomic systems of diesel generators serving mini-grids.

In 1992, Brazil's Renewable Energy Rural Electrification Project led to the installation of wind turbines and solar panels in more than a thousand villages and towns, a feat since replicated elsewhere around the country. In 1999, the Brazilian government mandated the National Program for Energy Development of States and Municipalities (PRODEEM) to bring some form of electric power to approximately 20 million rural inhabitants without access to grid power. It aims to facilitate the required US$25billion of investments to do so through a 'broad set of partners and third parties', focussing on the use of renewable energy sources. A number of international agencies have so far contributed to PRODEEM's coffers, including Multilateral Investment Fund and the Inter-American Development Bank, though on a much more modest scale than that foreseen to be necessary by the government.

PRODEEM is concentrating on market studies and field testing (demonstration projects) of various end-use applications, for example solar-powered icemakers. Partnerships with private sector companies will "help establish a thriving and sustainable renewable energy service market in Brazil" at community schools, health centres, water pumping and irrigation, street lighting, and other public needs.

The government is also tackling supply shortages by legislating for energy efficiency investments in electricity infrastructure. The government program PROCEL requires all electricity distribution licensees to invest one percent of their revenues in energy efficiency activities. One source estimates that in 1999, US$80 million invested under PROCEL saved 2,000 GWh of electricity. Opportunities may therefore exist for Pacific Northwest companies to approach such companies with innovative proposals for such mandated investments.

With an average price of electricity of $83 / MWh in 1999, Brazilian unit power cost is roughly double the value of that of the Pacific Northwest.

While each of these features may appear promising to some Pacific Northwest clean energy companies, a number of difficulties remain in carving a market in Brazil. Local partner companies would most likely be

required to negotiate Brazil's extensive and often tortuous tax regimes and regulations, as well as to take advantage of many of the government incentives for clean energy. Untransparent legal systems and corruption are also cited as problems when doing business in Brazil.

IEA's projections for solar power will incorporate PRODEEM's intention to install 50MW of photovoltaic power throughout the country by 2005. The country's sole domestic photovoltaic cell manufacturer, Heliodinamica, has proven unable to compete with primarily US-dominated imports, despite government help.

Brazil may also prove to be a major testing ground for the next generation of biomass power technologies: The Global Environment Facility (GEF) has co-sponsored a major biomass power project, using state-of-the-art biomass integrated gasification (BIG) technology. The 32MW plant will primarily use eucalyptus chips; consortium members include Electrobas, the Brazilian electric power agency, and Shell Brazil. Biomass is, of course, widely used throughout the country for primary energy, and biomass fuel production is a major industry.

Conclusion

Brazil is in desperate need of foreign investment and technology deployment in its electricity infrastructure, a need that encompasses both on-grid and off-grid applications. Electricity provision is currently the major priority of federal government; this despite the fact that, according to the Brazilian Association of Infrastructure and Basic Industries (Abdib) there are currently 785 electricity sector projects worth US $90.8 billion in the planning stages through to 2003.

Nevertheless, translating this need into opportunities for Pacific Northwest will remain a challenge. Higher tech solutions for energy efficiency in electricity transmission applications appear to be an opening, given the mandated requirement for such investment through the PROCEL program.

Germany

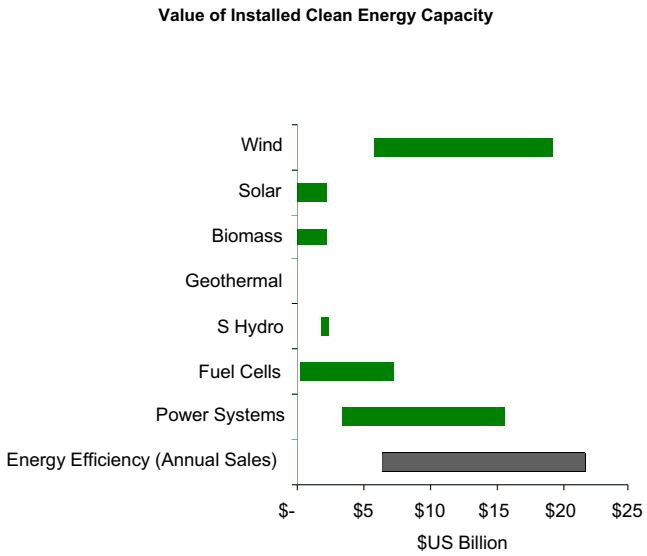
A global leader in the development and deployment of clean energy technologies, the German clean energy market is among the most dynamic in the world. Nevertheless, some Pacific Northwest companies may be able to compete on this industry giant's home turf.

The IEA suggests that Western Europe will be the largest single market for clean energy technologies over the coming twenty years. Germany is by far and away the largest single clean energy user in Western Europe; some 45% of the EU's wind capacity was installed there in 1997, for example. Since then, the industry has continued expanding at a tremendous rate.

Surveys of the Pacific Northwest clean energy industry found that Western Europe is seen as the most important likely future international market for its products and services. In this analysis, the focus is on the opportunities and issues Pacific Northwest companies will face in doing business in Germany, as an example of a Western European market.

Market size and potential

Chart 17: Clean Energy in Germany, 2000 to 2020
(Sources: IEA, ADL, ONL, EREN, EU ATLAS, EIA, EUROREX)



The German market for wind is substantial, and looks likely to continue to grow. By 2020, some $2 billion is forecast to be installed in both solar and biomass industries. Fuel cell use will be large due to automobile applications.

Market background

In Germany, the concept of clean energy has entered mainstream public discourse in a way that would seem strange to most North Americans. Politicians talk of

an ongoing process of Energiewende or 'energy transition', and targets for economy-wide renewable energy shares of 10% and 50% have been set for 2010 and 2050 respectively. This is considerably more ambitious than the EU as a whole, which plans to raise the share of renewable energy from 3% to 6% of total by 2010 – itself requiring an estimated $ 30 billion.

A number of drivers have led to this situation, not least of which is the country's heavy dependence on coal for much of its industrial and utility power supply. Regardless, Germany has long reaped the benefits of proactive policies towards clean energy, and is now home to a number of globally dominant or highly competitive clean energy industries.

According to one source, for example, the German wind power industry has created up to 20,000 jobs to date. Almost US$ 1 billion was invested in the German wind sector in 1998 alone, though an annual average of $670 million to 2020 looks most likely. Similarly, at least three major solar photovoltaic plants (15-25MW pa production capacity) are either in construction or have recently been completed over the last two or three years, and annual sales of photovoltaic components have been estimated at around US$ 2 billion. German firms are equally taking a lead in several biomass-related technologies, including biomass integrated gasification (BIG) plants, considered by some to be the next-big-thing in large scale renewable (if not all together clean) power production. A recent study showed that three times as many jobs are being created in the renewable energy sector than in the traditional energy generation sector.

For all this, however, the local market for clean energy continues to face challenges. Despite a relatively high average electricity price of US$71/MWh, renewable energy is still not fully cost competitive, and investments continue to be driven by the country's Electricity Feed Law (EFL). This defines payment and purchase obligations on behalf of utilities for electricity generated from renewable sources, the specific requirements for which have been tweaked over the years since its inception in 1991. This exposure to government influence represents an investment risk; the IEA also continues to be critical of the Feed Law's tendency to lack transparency and to cushion the market forces that would otherwise help drive down production costs.

In addition, Germany has substantial excess power generating capacity (up to as much as 45%). The EIA points out that major electricity companies recently have announced intentions to decrease generation capacity and output, and new power plant construction is at record lows.

The German electricity market is, however, opening to some retail competition, and a number of utility companies are offering 'green power' packages to a customer base that, research suggests, is willing to pay considerable premiums for the privilege. Unfortunately, as in many parts of North America, utility companies are often accused of charging clean energy producers prohibitively high rates for grid access.

Although almost completely open to North American trade and investors, the US State department notes that "Germany's regulations and bureaucratic procedures…can prove a baffling maze, blunting the enthusiasm of US exporters. While not discriminatory in the classic sense, government regulation is often complex and may offer a degree of protection to already-established local suppliers".

Conclusions

Penetrating the German clean energy market might seem daunting, but there is every reason to believe that some Pacific Northwest firms may be able to carve niches in this large and wealthy part of the world.

Germany manufactures a range of end use applications for fuel cells, for example, including cars and heating devices, but at present looks likely to import fuel cell stacks from North America (Siemens' recent merger with solid oxide fuel cell technology leader Westinghouse notwithstanding). There are no major funding agencies nurturing fuel cell development, and many German fuel cell proponents gaze enviously at North America's state support of fuel cell development.

Germany is also generally receptive to North American high technology products and services, and power systems firms in the Pacific Northwest may well find opportunities here.

Individual Technology Evaluations

Introduction

In this section, each clean energy technology is examined along with the current Pacific Northwest capabilities in those technologies to help reveal the potential for firms in the Pacific Northwest to achieve global competitiveness. The following opportunities are examined (in no particular order):

- wind
- geothermal
- biomass
- small hydro
- solar
- fuel cells
- power system technologies
- energy efficiency (including energy management services)

This list is not intended to be exhaustive. Some classes of technology have not been formally evaluated, either because little information was available or because they are very far from commercialization. For example, Blue Energy Canada, based in Vancouver BC is developing leading technology in tidal power. However, wave and tidal power technologies are still in very early stages of development. Most analysts agree that these technologies are unlikely to develop into a major global industry before 2020.

The following seven criteria are used to assess the possibility of establishing an export-oriented industry within the Pacific Northwest:

1. Size, accessibility and growth of key markets
2. Stage of technology development
3. Competitive position of Northwest
4. Economic leverage
5. Synergies with other energy technologies
6. Workforce synergies
7. Local supply potential

Table 2 summarizes the performance of each technology against each criterion. The criteria and evaluation system are described in greater detail in the legend at the end of this report.

Discussion

Wind power is, and for some time will continue to be, a major component of the Pacific Northwest's supply of clean energy. This is good news to local installers, maintenance technicians and steel foundries (some of whom will be required to manufacture towers).

Wind will expand rapidly in key markets, including North America and Asia. However, while wind turbines may be a highly visible manifestation of clean energy here, it is the manufacturers of these turbines and associated system components, primarily located in California, Denmark and Germany, who will provide the equipment – and reap the largest benefits in terms of investment and jobs. Furthermore, wind turbine technology has advanced to an extent that it would be difficult, if not impossible, for the region to catch up if it were to begin to develop significant research and development capacity. Wind technology may still have further to develop, but incumbent market leaders are ever more likely to be the firms undertaking this research: as the sector becomes evermore capital intensive, it is likely to consolidate over time, raising further barriers to new market entrants in all but niche applications.

Geothermal energy – both in the form of electricity and direct heat – can be produced from a variety of different heat sources and grades. Globally, the largest share of geothermal value will come from power generation, which is likely to expand strongly over the coming twenty years, particularly in the Philippines, Indonesia, Japan and California. British Columbians may soon benefit from geothermal power at a site near Meagher Creek, but this will likely be developed using Californian or Japanese equipment and expertise.

Biomass energy comes in the widest range of forms, and in many ways it is problematic to treat it as a single industrial sector. On the power supply side, international firms with long-established stakes in new forms of coal combustion, such as Integrated Gasification Combined Cycle systems, look likely to apply this knowledge to parallel (and more complex) Biomass Integrated Gasification Combine Cycle (BIGCC) systems. Although the region has at least one small company with some expertise in actual production technologies, the outlook for developing biomass fuels is somewhat more promising. Companies

such as Pyro Industries (biomass fuel pellets), Dynamotive (biomass fuel oil) and various ethanol producers in the region, combined with abundant resource potential and synergies with the forest industry, may help the region develop a presence in biomass fuel development. However, these companies represent a relatively small industry base from which to develop the Northwest as a centre for biomass fuel production, and global competition in biofuel production is particularly fierce. Plus, much of the "value" that is available in biomass is in the collection and handling of the fuel, an activity that is relatively low value-added and likely to occur onsite.

Small hydropower will see strong and steady growth over the coming twenty years, as interest in less environmentally damaging hydropower continues to grow across the globe. The Pacific Northwest has good representation in this industry, mainly from either large corporations with minor interests in hydropower or from small companies dedicated to the technology. Locally-based Raytheon Infrastructure, a subsidiary of defence giant Raytheon, is one of the world's leading small hydro contractors. Small hydro, however, is a relatively mature technology that is unlikely to see huge gains in performance over coming years. Those gains that do come are likely to originate from broader system integration and control technologies, which are included within power system technologies for the purposes of this analysis.

The Pacific Northwest has a presence in developing and manufacturing both solar photovoltaic cells and stand-alone systems. The local division of Siemens Solar is a world leader in the development and manufacture of silicon ingots, and the parent company is a leading developer of thin film technology. JX Crystals is developing infra-red photovoltaic technologies and Xantrex and Applied Power integrate photovoltaic components with batteries to form standalone solar power systems. Meanwhile the University of Oregon in Eugene is home to one of the leading researchers in thin film technology and many smaller companies are developing related systems or components. More importantly, solar photovoltaics is at an ideal stage of technology development with recent breakthroughs in thin film helping to increase efficiencies and bring costs of the cells down. Inverter costs and storage costs are also coming down, and installation costs are also falling due to better design and new licensing programs for installers. There are also a number of synergies between solar photovoltaics, fuel cells and power system technologies, and synergies with the broader hi-tech sector and workforce in the Pacific Northwest.

The region is unquestioningly one of the global leaders in fuel cell development. Firms such as Ballard have well-established global reputations. But the Pacific Northwest also has a large number of smaller fuel cell companies, such as Idatech in Oregon, each with the potential to develop into high value operations.

Although fuel cells have yet to become fully commercialized, it looks likely that transport and power applications will be generating sales in the near term. As an established centre of fuel cell research and development, the Pacific Northwest is poised to be among the first to benefit from this new market, creating a range of local high-value knowledge-based employment opportunities. Spin-off industries are likely to follow from this, as are spin-off benefits for the clean energy industry, particularly with solar photovoltaics and other intermittent sources (as a storage option) and power systems technologies (through related controls technologies).

Power systems technologies encompass a wide range of advanced technologies that contribute to the improvement of electricity transmission, storage, measurement, conditioning, control, and communications. By collectively reducing losses, increasing the amount of final energy that is produced and delivered from a given infrastructure, and increasing reliability and power quality, power systems technologies will increasingly make a major contribution to the development of cleaner power.

The Pacific Northwest has much to gain from fostering its power systems technologies sector. Potential markets are large, and industry development would create high value jobs and nurture workforce skills that would be transferable across other high tech sectors. The region is currently well represented in power systems technology development, and is expected to deliver significant investment returns in the short to medium term.

Leading firms in the Pacific Northwest, including Power Measurement and, again, Xantrex, will help the region play a major role in the development of this sub-sector.

The Pacific Northwest also has a strong presence in the energy efficiency technology sub-sector. Although the energy efficiency currently makes a larger contribution to local economic development than all the clean generating technologies put together, it does not translate easily into value-added from an export perspective. There is relatively little economic leverage, for example, in developing a presence in retrofitting buildings overseas. Most of the labour in this case will be based overseas. And as far as appliance development is concerned, most of that presently occurs outside the region. There may be certain hi-tech sub-components of the energy efficiency market (e.g., advanced energy management systems and building components) that could be specifically targeted in the region, but these would need to be evaluated on a case-by-case basis. In sum, the efficiency sector is a very important component of a healthy local economy, but it is pervasive and embedded within other products thus making it hard to leverage and nurture as an export industry.

Conclusions

The Pacific Northwest's wind power, small hydro, biomass energy and energy efficiency industries will undoubtedly be important to job creation and to meeting local energy supply needs long into the future. They represent a good majority of the region's clean energy sector, and play a crucial role in protecting the region's environment from unnecessary harm.

However, the technologies that present the best opportunity for the Pacific Northwest to develop a global clean energy industry are fuel cells, power systems technologies and solar photovoltaic system industries.

In addition, these three technologies have significant mutual synergies. Solar photovolatics, for example, require power systems technologies in the form of storage to function as a standalone resource. Fuel cells can also act as a storage medium, and offer power systems developers an option in developing high power quality applications. Power systems technologies will also make it easier to control and dispatch stationary fuel cell or photovoltaic power plants remotely.

In sum, these three constitute a formidable combination because each has:

- Demonstrated Pacific Northwest industry leadership;
- High leverage in terms of potential economic value added;
- Nascent industry clusters are already emerging around these technologies;
- Strong potential synergies with each other and other clean energy technologies; and
- Strong synergies with the region's broader high-tech sector.

Table 1: Technology Summary Evaluation

		Wind	Geothermal	Biomass	Small Hydro	Solar	Fuel Cells	Power System Techs	Energy Efficiency
⇑ Favour industry development	Size, accessibility and growth of key markets	◒	○	◒	◒	◒	●	●	●
	Stage of Technology Development	○	◒	◒	○	●	●	●	○
	Competitive position of Northwest	○	○	○	●	◒	●	◒	◒
	Economic leverage	◒	◒	◒	◒	●	●	●	○
⇓ Favour supply	Synergies with other energy technologies	◒	○	◒	◒	◒	●	●	◒
	Workforce Synergies	◒	◒	◒	◒	●	●	●	○
	Local supply potential[1]	◒	○	◒	◒	○	◒	●	●

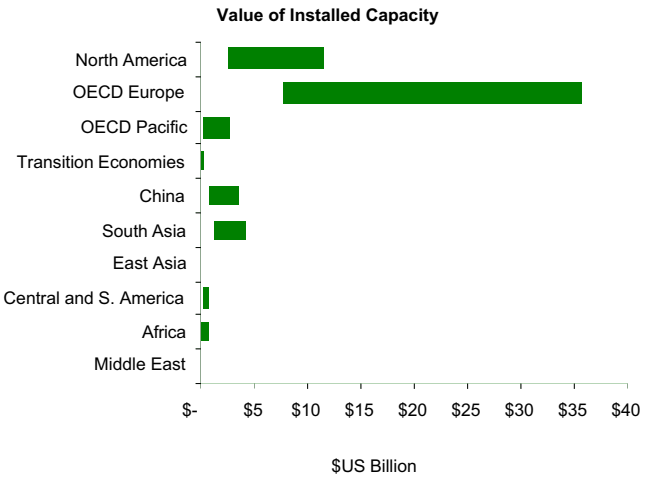
See page 54 legend and description

1. These evaluations are for the region as a whole and may differ by sub-region. For example, for small hydro supply potential is good in BC, but limited in Washington and Oregon. And for solar, supply potential is better in Oregon and Washington than in BC

Wind Power

Chart 18: Wind, 2000 to 2020

(Source: IEA)



Technology Description and Developments

Impressive advances in utility (>500kW), village (50-500kW) and micro-scale (<50kW) turbines have seen components have become lighter, more robust, fewer in number and less demanding of maintenance. Corresponding integration and control technology advances have also lead to performance improvements. Advantages: public perception as a clean technology, low maintenance; Disadvantages: high capital cost, low capacity factor and highly-site dependent performance.

Market Overview

Wind power is emerging as a mainstream power generation technology. The levelized cost of wind generation has fallen from around 100 $/MWh in 1990 to around 50-60 $/MWh today, and further reductions look likely. The global market for wind power will expand from around $15 billion in 2000 to about $60 billion over the coming twenty years. The vast majority of this growth will be in Europe, whose firms dominate the global wind industry.

Wind Farm (Source: NREL)

Pacific Northwest Companies

- Global Energy Concepts (WA)
- Wind Turbine Company (WA)

Global Industry Leaders

- NEG Micon (Denmark)
- Vestas (Denmark)
- Enercon (Germany)
- BONUS Energy (Denmark)
- Gamesa (Spain)
- MADE (Spain)
- Nordex (Denmark)

⇑ Favour industry development	Size, accessibility and growth of key markets	Strong global growth anticipated, including key potential Pacific Northwest markets such as North America, China, Japan and India.
	Stage of Technology Development	Mature technology (relative to other clean technologies)
	Competitive position of Northwest	The region has no leading firms in turbine manufacturing, component manufacturing or project development. Due to high capital costs and rapid pace of technical innovation, greatest value is in the research/manufacturing element of the value chain. The region is currently in a poor competitive position relative to global competitors, perhaps irrevocably.
	Economic leverage	Wind power development in the region would provide important installation and service jobs, but relatively few value-added R&D or manufacturing jobs.
	Synergies with other energy technologies	Synergies with storage (power shaping and off-grid applications), monitoring, and control technologies.
	Workforce synergies	Some workforce synergies may exist - aerospace and information technology company skills may transfer.
⇓ Favour supply	Local supply potential	The region's good wind resource potential (particularly in Washington) and need for increased power supply will ensure that it will be among the leading wind supply regions in North America. However, current rate of growth will not be sustainable once prime locations have been developed.

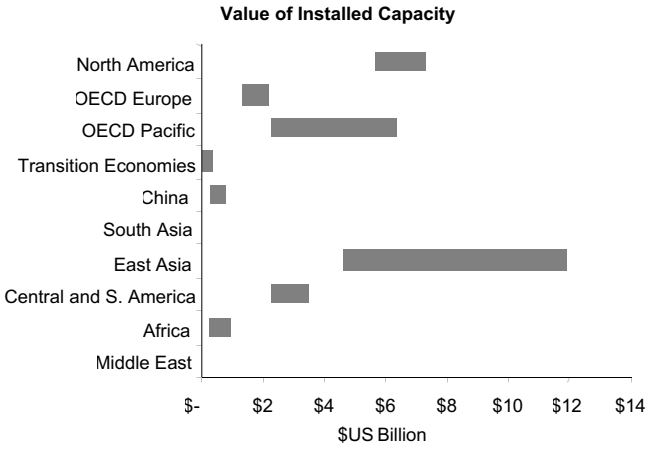
Conclusions

The large global, North America and local markets (primarily Washington State) for wind presents an opportunity for the NW to become experts in the installation and operation of wind. But this alone would not build a value-added local R&D or manufacturing industry in wind. To do so the Pacific Northwest would need to establish global dominance in the knowledge and manufacture of wind energy components, an industry that is relatively mature and is dominated by well-established competitors.

(See legend at end of this report for explanation of the symbols)

Geothermal Power

Chart 19: Geothermal Power, 2000 to 2020
(Source: IEA)



Technology Description and Developments

A range of technologies at varying stages of development in which geothermal heat is collected and converted to electrical energy or used directly as heat. *Note: ground source heat pumpsand district heating are considered separately as an efficiency technology.* Existing plants use steam to exploit relatively shallow resources; future 'hot dry rock' technology (HDR) will make use of deeper, more abundant sites. Advantages: High capacity factors, clean, very large potential. Disadvantages: high capital cost, site-specific.

Market Overview

Globally, most geothermal capacity will be installed in the Philippines, Indonesia and Japan. The IEA estimates that global installed capacity will increase from $15 billion to $35 billion between 2000 and 2020. Although the Pacific Northwest (including Idaho and Montana) has a theoretical potential to generate up to 11GW of electricity from geothermal sources (RNP 2001), there are no current plans to develop geothermal power in the region, though one site in BC is under serious consideration. The DOE plans to promote geothermal power development through its "Geopowering the West" program, which focuses mainly on California, Nevada and Utah. The Pacific Northwest has no leading geothermal power firms.

Geothermal Power Plant (Source: NREL)

Pacific Northwest Companies

- Crew Development Corp (BC) (mining company with potential interest in developing a BC-based power facility)

Global Industry Leaders

- CalEnergy (US)
- CalPine (US)
- Ben Holt Company (US)
- Mitsubishi Heavy Ind Ltd (Japan)
- Geothermal Power Co (US)

⇑ Favour industry development	Size, accessibility and growth of key markets	Some growth anticipated in western US (California, Nevada and Utah), Pacific Rim.
	Stage of Technology Development	Current commercial technology somewhat mature, though potentially important HDR technology is still in development stage
	Competitive position of Northwest	The region has no leading firms in geothermal power plant equipment, direct use systems or manufacture.
	Economic leverage	There are R&D opportunities remaining in geothermal, but given the site-specific nature of geothermal these are likely to be best located near major sources of supply.
	Synergies with other energy technologies	Geothermal power is a baseload application, and therefore has fewer of the industry synergies associated with intermittent sources, but it will benefit from improvements in transmission.
⇓ Favour supply	Workforce synergies	Possible workforce synergies may exist in the mining and resource exploration sector.
	Local supply potential	Without advances in HDR technology, supply potential in BC, Washington and Oregon is limited. The region has only one potentially significant geothermal power plant site at present.

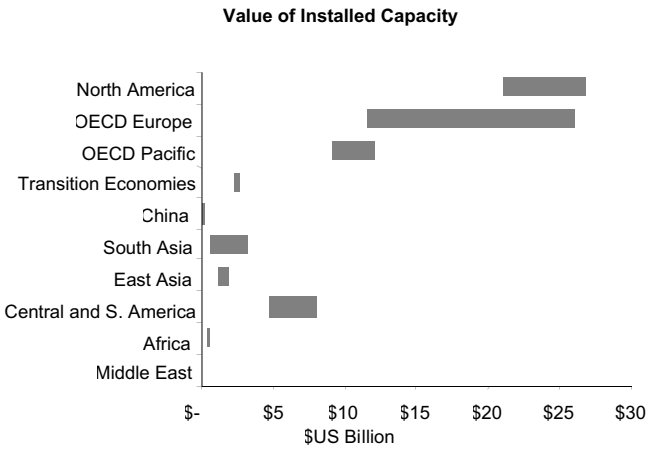
Conclusions

In North America, geothermal power supply is primarily taking root in Utah, Nevada and California, whose companies play a leading role in a (currently small) global industry. A geothermal power plant at Meagher Creek in BC may be developed over the coming years, with a capacity in the range of 60-250MW, depending on the results of technical studies. Although the Pacific Northwest has some supply potential that may be exploited when technology has advanced, its firms are currently playing no major role in developing those technologies.

Biomass Energy

Chart 20: Biomass Power, 2000 to 2020

(Source: IEA)



Technology Description and Developments

Biomass energy can take a variety of forms, from high-tech thermo-chemical or biochemical conversion technologies and advanced gasification and combustion systems to the use of animal and plant waste use in domestic stoves. In power production, Biomass Integrated Gasification Combined Cycle (BIGCC) technologies may improve competitiveness through increased efficiency and environmental performance. Bio fuels may begin to replace or augment fossil fuels in some applications. Advantages: mostly GHG neutral, large potential, particularly in the developing world. Disadvantages: public perception as a dirty technology, local air quality impacts (real or perceived), low fuel energy density (and consequently high land use and fuel transportation requirement).

Market Overview

Modern biomass electricity generating systems may soon be a full-scale global energy option, though significant technological, fuel processing and supply infrastructure problems remain. In North America, most current biomass power production occurs in the forestry sector, and only a handful of standalone or utility biomass power plants exist in the region. The value of total installed capacity is expected to increase from $50 billion in 2000 to $80 billion in 2020.

Biomass Power Plant (Source: NREL)

Pacific Northwest Companies

- Dynamotive (Fuel Oil - BC)
- Heuristic Eng (Gasification -BC)
- Pyro Industries (Pellet stoves, WA)
- Travis Industries (Fireplace burner systems, WA)
- Numerous forest products companies

Global Industry Leaders

- Lurgi (Germany)
- Bioflow (Sweden/US)
- Noell (Germany)
- TPS Termiska (Sweden)
- Carbona (Finland)

⇑ Favour industry development	Size, accessibility and growth of key markets	There are key market opportunities in North America, Central and South America and Pacific Rim countries, all of which are large and accessible markets to Pacific Northwest firms
	Stage of Technology Development	While some direct combustion technologies are relatively mature, other, more sophisticated gasification and conversion systems are in the development/early commercialization stage. Biomass Integrated Gasification Combined Cycle (BIGCC) technology will probably be a competitive large-scale power source in the next 10 to 20 years. Various biomass fuel production technologies are in an early stage of commercialization.
	Competitive position of Northwest	No significant local capacity in BIGCC systems, which are widely regarded as being the next major technology development in bio-power generation. Some capacity in ethanol and other biofuel production
	Economic Leverage	Some components of advanced biomass technology development could generate R&D and pilot manufacturing economic spin-offs, but a large proportion of biomass investment is site and fuel specific and would happen outside the Pacific Northwest.
	Synergies with other energy technologies	Through thermochemical and/or biochemical processes, biomass fuel sources could be used to produce high-value fuels such as ethanol for transportation or hydrogen or methanol for fuel cell use.
	Workforce synergies	The Pacific Northwest has significant indigenous skills in the forest sector and already a number of plants that use traditional technology.
⇓ Favour supply	Local supply potential	BC and Oregon have significant woodwaste supply potential and the region has a mature infrastructure for the development of biomass resources. Much depends on the development of a market for biomass fuels such as ethanol.

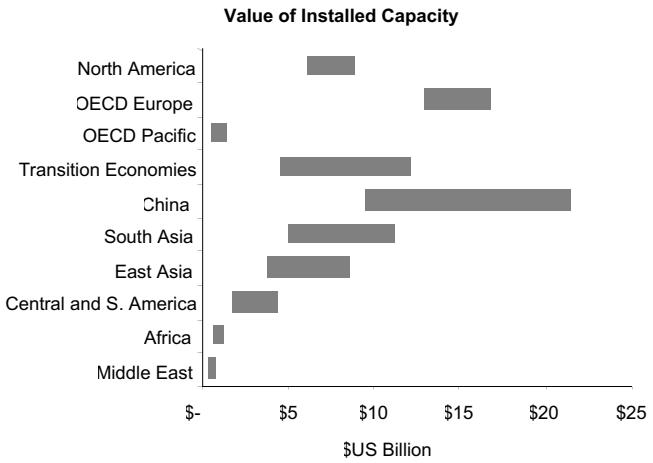
Conclusions

Electricity production from biomass, currently dominated by the forest products industry, is unlikely to become fully competitive at a utility level until the development of BIGCC systems. Although the Pacific Northwest may be able to provide technology and raw material related to fuel production, it seems unlikely to play a major role in development of the actual generation technology. The region may contribute more to the development of biofuels from woodwaste, though both markets and technologies for such fuels remain undeveloped.

Small Hydro Power

Chart 21: Small Hydro, 2000 to 2020

(Source: EU ATLAS, IEA)



Technology Description and Developments

Small hydropower facilities are taken here to be systems smaller than 10MW, though the terms micro- and mini-hydro are sometimes used to further differentiate systems smaller than 400kW or 1MW, respectively. All hydropower plants convert the kinetic energy of water falling under gravity directly to electrical energy. Although large hydroelectric plants continue to be constructed in North America and throughout the world, only smaller facilities are generally considered to deliver 'clean' energy because of environmental and social justice considerations. Efforts are focused on lowering production costs of turbines, integrating more advanced technologies (e.g. variable speed turbine generators, advanced control systems), and streamlining installation. Advantages: Low environmental impact, low operation and maintenance costs. Disadvantages: Often widely variable capacity factors, resource locations rarely coincide with demand locations.

Market Overview

The global industry is currently expanding by around $1 billion per year, and will reach a total installed investment of $25 billion by 2020. Many developing countries manufacture their own smaller units; more advanced technology is required only on larger (>1MW) systems.

Small Hydro Power Plant (Source: NREL)

Pacific Northwest Companies

- Canyon Industries (WA)
- Dependable Turbines Ltd (BC)
- Hydro West Group (WA)
- WA Thomson & Howe Energy Systems (BC)
- A range of large civil engineering firms (e.g. Raytheon Infrastructure Inc. in WA)

Global Industry Leaders

- ABB Power Gen (Switzerland)
- American Hydro Corp (USA)
- BHS-Cincinnati Getri. (Germany)
- GEC Alsthom (France)
- Sulzer (Switzerland)
- Kvaerner (USA)
- Raytheon Infrastruct. Inc (USA)

⇑ Favour industry development	Size, accessibility and growth of key markets	At least forty countries, mainly in Asia and Europe, have small hydro plants under construction and even more have plants planned. (WEC).
	Stage of Technology Development	Small hydro is a mature technology with little potential for significant advancements (ADL). Some advances may include application of large hydro technologies on a smaller scale, e.g. use of variable speed turbines at low heads (WEA), as well as use of inflatable weirs to regulate water level / raise dam's crest to increase capacity factors (ADL).
	Competitive position of Northwest	The region has some leading firms in the industry, at least one of which is globally recognized.
	Economic leverage	As a mature technology, the value chain focus is shifting from system and component design to project development and installation.
	Synergies with other energy technologies	Major synergies with large hydropower. Potential synergies with power system technologies, including transmission advances (integration of remote sites), monitoring, control and storage technologies (for off-grid applications or optimization of interconnections).
⇓ Favour supply	Workforce synergies	The Pacific Northwest has considerable experience with large hydropower development, operation and environmental management, much of which will transfer to smaller-scale applications.
	Local supply potential	There is a theoretical potential for several GW of small hydro in the Pacific Northwest but roughly 1 GW is expected to be installed by 2020, with the majority in BC

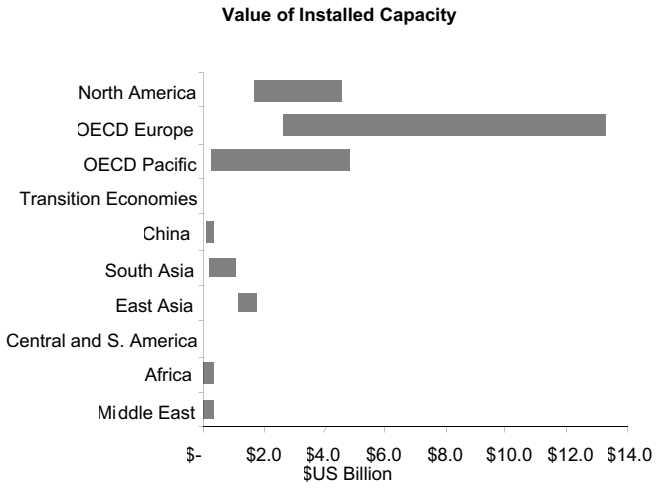
Conclusions

Although the Pacific Northwest has considerable natural resources and workforce skills associated with hydropower, the technology is relatively mature and added value will be increasingly difficult to find; manufacturing cost reduction is increasingly a primary focus. As premium sites near sources of demand are developed, margins on subsequent local projects are likely to decline.

Solar Power

Chart 22: Solar Photovoltaics, 2000 to 2020

(Source: IEA)



Technology Description and Developments

Two main technology types are wafer-type (based on silicon) and thin film (deposited directly on substrate material). Single crystal silicon (sc-Si) and Multi-crystalline silicon (mc-Si) make up 85% of 1998 market, and Amorphous silicon (a-Si) 13%. Thin film technologies offer the potential for low-cost mass production (integrated with other components such as building cladding). The share of photovoltaic cells that are ultimately employed in grid-based power applications increased from 11% in 1990 to 23% in 1998 (Off-grid and consumer goods comprise the balance) (WEA). Advantages: Very low operational costs and environmental impact. Disadvantages: High capital cost (presently), somewhat site-dependent

Market Overview

The most promising applications for solar power are grid-connected or standalone systems in rural or remote areas, or as cladding for commercial buildings or housing complexes. The US and Japan are major market players, with European companies contributing only 21% of market in 1996 (EU). However, the chart shows that Europe will be the major global market for solar power, and will be home to more than half the world's installed capacity by 2020, by which time a total of $25 billion will have been installed.

Solar PV (Source: NREL)

Pacific Northwest Companies

- JX Crystals (Infra-red PV, WA)
- Schott Applied Power (WA, Parent Co in NY)
- Siemens Solar (WA manuf for CA-based subsidiary of German co)
- Xantrex (BC, includes Trace Engineering (WA subsidiary)

Global Industry Leaders

- Amoco-Enron Solar (US)
- Applied Power (US)
- BP Solar (UK)
- Eurosolare (Italy)
- Siemens Solar (US)
- Solec (Japan)
- Sun Power Electric (US)
- Xantrex (Canada)

⇑ Favour industry development	Size, accessibility and growth of key markets	The global market for solar power is an order of magnitude smaller than, the wind or small hydro industry. However, the Pacific Northwest has relatively good access to some key markets in the Pacific Rim.
	Stage of Technology Development	Although solar power technology has come a long way over the past two decades, it still has much further to go. Beyond 2010, thin film technologies will develop at a rapid pace, bringing large reductions in levelized costs of electricity.
	Competitive position of Northwest	The Pacific Northwest has a strong position in the current stage of technology development. It is represented on a global level by a number of key firms. However, the pace of technology development is such that such a position cannot be taken for granted.
	Economic leverage	Further cost reductions in solar photovoltaic manufacturing will require significant R&D in materials, design and control and will thus bring with it a large number of spin-off industries and associated economic benefits.
	Synergies with other energy technologies	Solar energy will benefit from the development of improved end use efficiency (better match between production and use) and other power system technologies such as storage technologies.
	Workforce synergies	Solar technology development draws on many Pacific Northwest workforce strengths, such as advanced materials production, electronics and communications.
⇓ Favour supply	Local supply potential	Over the longer term (beyond 2020) the region has a relatively high potential for solar power. In eastern BC, Oregon and Washington, solar flux is comparable to many parts of Europe (e.g. Germany) that have considerable installed capacity.

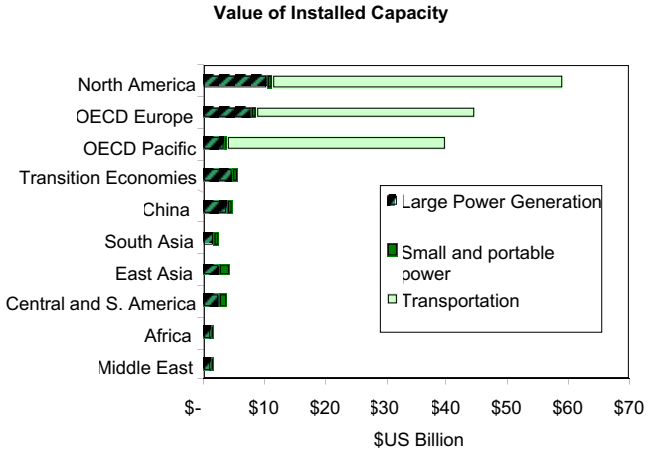
Conclusions

Solar power is likely to make a major contribution to world energy needs in the longer-term future. Given the region's current presence and industry / workforce synergies, the Pacific Northwest has an opportunity to establish itself now as major player in this future market.

Fuel Cells

Chart 23: Fuel Cells, 2000 to 2020

(Source: ADL, Fuel Cells Canada)



Technology Description and Developments

Fuel cells are a conversion technology that converts chemical energy directly into electrical energy and heat. They require an external fuel source. Several types of fuel cell technologies are in development. Proton exchange membrane fuel cells (PEMFC) are felt to be well suited to the transportation market, though are also being developed for small and medium sized stationary power applications. Phosphoric acid fuel cells (PAFC), molten carbonate fuel cells (MCFC), and solid oxide fuel cells (SOFC) are more suited to combined heat and power applications, while direct alcohol fuel cell (DAFC) is well suited to portable applications. Many also think DAFC is a good candidate for the automobile. Advantages: High efficiency, low maintenance and low emissions at point of use. Disadvantages: Supply and storage of fuel.

Market Overview

Most commercially installed stationary fuel cells to date are PAFCs. More promising long-term technologies are considered to be SOFC, DAFC and PEMFC, which are now being widely tested in the field and in some cases have entered limited commercial applications. By 2020, the overall installed capacity could be worth $170 billion.

ONSI PAFC (Source: NREL)

Pacific Northwest Companies

- Avista (WA)
- Ballard (BC)
- Cellex (BC)
- Idatech (OR)
- Innovatek (WA)
- Questair (BC)
- Xcellisis (BC)

Global Industry Leaders

- Ballard (Canada)
- Exxon Mobil (US)
- International Fuel Cells (US)
- Siemens (Germany)
- Westinghouse (US)

⇑ Favour industry development	Size, accessibility and growth of key markets	Applications include storage, transportation, stationary power production, and combined heat and power (large an small). Applicability to the auto sector is the major wild card. Many are depending on it, while many others expect it to fail.
	Stage of Technology Development	Technology is expected to be in widespread use by 2010, but significant further development and improvements in the technology are expected beyond 2020.
	Competitive position of Northwest	The Pacific Northwest is a global leader in PEM technology, and has several complementary companies throughout the region developing components or applications.
	Economic leverage	Many spin-off industries associated with fuel cells. Examples include engines, fuel delivery, storage, electric drive trains, and controls. Once established, routine manufacturing of fuel cell stacks for autos will likely take place in near auto manufacturers, but the R&D and pilot manufacturing could remain in Pacific Northwest.
	Synergies with other energy technologies	Successful deployment of fuel cells will require fuel, storage and related control technologies. Fuel cells may also act as a form of distributed energy storage, facilitating the economic development of renewable energy sources such as biomass, wind, and solar.
⇓ Favour supply	Workforce synergies	Majority of product relies on advanced technology.
	Local supply potential	Some power quality applications in the Pacific Northwest, but the economics will be stronger in other regions that have higher costs of generation, and higher T&D constraints

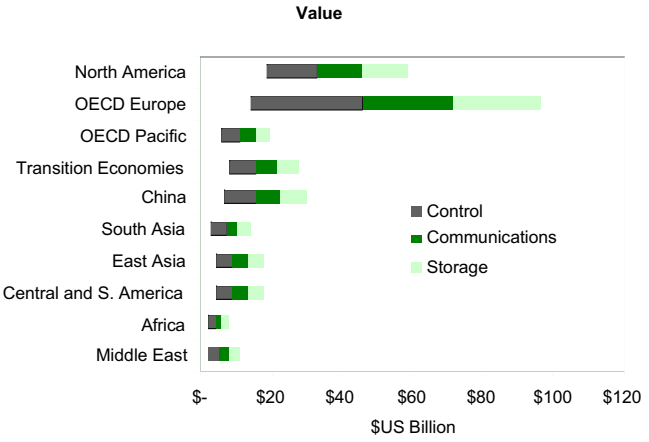
Conclusions

Fuel cells and the industry associated with fuel cells present a significant opportunity for the Pacific Northwest to establish an industry. The potential market is large, the technology is at an ideal point in its development (i.e. just becoming commercial) and the Pacific Northwest has a dominant global player plus a number of strong supporting companies. Successful development of fuel cells would also draw skills and technology to the region that would benefit other clean energy producers.

Power System Technologies

Chart 24: Power Systems, 2000 to 2020

(Source: IEA, ADL, ONL)



Technology Description and Developments

Power system technologies encompass a wide array of transmission, storage, measurement, conditioning, control, and communications technologies (IT). Together these technologies support reduced transmission costs, increased reliability and improved power quality.

Market Overview

The Electric Power Research Institute estimates pooled R&D (albeit in an EPRI program) will need to climb to $1billion/yr by 2010 to meet the needs in this area. In addition to that, global investments in actual infrastructure are expected to exceed $100 billion over the next 20 years.

Global installed capacity, currently at $70 billion, is forecast to rise to $300 billion by 2020.

Battery storage (Source: NREL)

Pacific Northwest Companies

- Adv. Power Technology (OR)
- Applied Power (WA)
- Linesoft (WA)
- Nxt Phase (BC)
- PacificCorp (OR)
- Power Measurement (BC)
- Tantalus (BC)
- Xantrex / Trace (BC/WA)

Global Industry Leaders

- ABB (Switzerland)
- Alstom (France)
- Messenwander
- NGK (Japan)
- Ritz
- Siemens (Germany)
- Trench (Canada)

⇑ Favour industry development	Size, accessibility and growth of key markets	There is no dispute that this market is large, but most agree it is difficult to say exactly "when" this market will take-off. There is already gradual investment, but there are still numerous institutional and market barriers to implementing advanced power system technologies.
	Stage of Technology Development	Many technologies are in early stages of development, but some are commercial today and significant commercial advances are expected by 2010.
	Competitive position of Northwest	With the possible exception of Xantrex, there are no existing large global leaders in this area. However, there is a number of world class technologies and partnerships with companies such as GE/Honeywell and ABB.
	Economic leverage	The majority of these products could be built here and cost effectively exported due to their large value to weight ratios and significant embodied R&D and skilled labour.
	Synergies with other energy technologies	Storage, controls and communication would have direct synergies with all forms of distributed and renewable generation.
	Workforce synergies	Major institutions and companies in the area are involved in advanced materials and software design.
⇓ Favour supply	Local supply potential	Local DG applications and capital stock turnover in the grid in general are expected to be higher elsewhere in the US and globally, but there are some bottlenecks that could be addressed here.

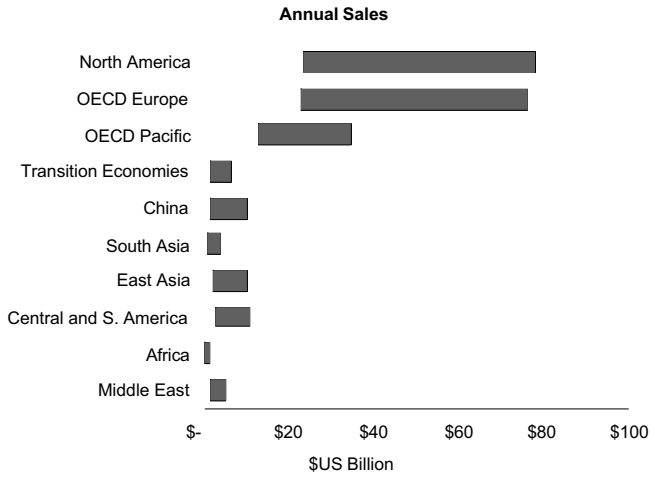
Conclusions

Technological advances, system standards, market restructuring, and customer demand will converge within the next ten years to break open the markets for these technologies. With its current base of technologies and skill sets, the Pacific Northwest could be well positioned to participate in those markets. And to the extent they do, this will complement other energy technologies of interest to the Pacific Northwest.

Energy Efficiency

Chart 25: Energy Efficiency, 2000 to 2020

(Source: EIA, EREN)



Technology Description and Developments

The energy efficiency and energy management services sector comprises a wide range of products and activities. Key segments are: 1) building components and construction, 2) space heating and cooling, 3) appliances, 4) energy management and 5) lighting. The sector is difficult to isolate because in many cases efficiency is simply an attribute of other products rather than a stand-alone product or service (e.g., a factor differentiating alternative appliance producers).

Market Overview

The market for efficiency is large, well established and growing. A reasonable proxy for the total size of market is the sector for building renovation, modification and repair. The current annual sales of energy efficiency technologies and equipment are estimated at around $70 billion per year; this will rise to over $200 billion per year by 2020.

Energy Efficient lightbulbs
(Source: NREL)

Pacific Northwest Companies

- Capstone Manufacturing (WA)
- Columbia Lighting (WA)
- Energy Saving Products (WA)
- Portland Energy Conservation (OR)
- Ledalite Architectural Products (BC)

Global Industry Leaders

- GE/Honeywell (US)
- Siemens (Germany)
- Phillips (Netherlands)

Size, accessibility and growth of key markets	The local market for efficiency products/services is large (roughly $1 billion/year), and there are substantial opportunities to participate in other key markets.
Stage of Technology Development	While some efficiency technologies are leading edge and have much opportunity for further development, most are relatively advanced or embedded within other low value products
Competitive position of Northwest	The Pacific Northwest has a large number of smaller companies, plus subsidiaries of major international companies
Economic leverage	Given that sector is comprised primarily of services or embodied in other products, the leverage opportunity for this sector is low
Synergies with other energy technologies	Some synergies exist with other clean energy technologies. For example, energy management systems can be used, with suitable incentives, to reduce loads and adjust load profiles to better match small, intermittent power sources.
Workforce synergies	With several exceptions for advanced technologies, the majority of products and services are relatively low-tech, and do not employ leading edge technical skills
Local supply potential	The overall size of this local market is around $ 1 billion per year, rising to over $3 billion per year by 2020.

⇓ Favour supply

Conclusions

Efficiency is considered key to any strategy to reduce the environmental impact of energy use, and the market potential for energy efficiency technologies and services is large, both locally and globally. However, while the Pacific Northwest has a number of good companies, it would be difficult to leverage this diverse, service-based industry into a position of leadership beyond home ground.

Part 2.
Policy Strategies:
How to Harness Clean Energy's Potential to Create Jobs and Power the Northwest Economy

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Introduction

Project Origins

In late 2000, representatives from a number of utilities and economic development agencies in British Columbia, Oregon, and Washington came together to discuss the future of the region's clean energy sector. From their work in the field they knew that the sector was growing rapidly and they believed that the combination of electricity deregulation, concern about climate change, threatened power shortages, and the technology sector's need for increasingly reliable power would spur even greater growth.

With continued growth, they reasoned, clean energy could become an economic development driver in the region, in much the same way that the high technology sector had expanded over several decades to become a significant source of jobs and business development opportunities. With that concept as a guiding principle – that clean energy could become an economic development tool as well as an environmental good – the project sponsors commissioned a market analysis to study the clean energy sector and its prospects for growth worldwide.

Next, the project sponsors turned their attention to public policy initiatives that could be implemented to help the clean energy sector achieve the levels of growth outlined in the market analysis. They were aware that earlier high technology ventures had been aided by policy initiatives including tax incentives, marketing assistance, and business development, and decided to develop a plan for public investment in the clean energy sector that was modeled on these existing high tech policy efforts.

Project Goals

Many of the clean energy efforts currently underway in the United States and Canada are focused on the use of renewable energy sources or the conservation of fossil fuels as an end result. These efforts aim to address potential power shortages, reduce the need for new power plants, or mitigate against air pollution, and therefore direct their policy proposals at specific opportunities to increase clean energy use.

The "Kicking off the Clean Energy Revolution" project, on the other hand, has a different focus. Its primary aim is to use clean energy as an economic development tool for British Columbia, Oregon, and Washington. Thus, while many of the policies in this paper do encourage the increased use of either renewable energy sources or energy efficiency technologies and services, the primary aim of the policies suggested in this paper is to stimulate the clean energy sector, helping both new and established businesses grow and thrive.

Because of this focus on economic development, this paper does not include the full range of clean energy policy initiatives that are often discussed in the context of encouraging clean energy. Instead, it focuses on those that appear to have the greatest potential to help clean energy as an industry, to stimulate private investment, business development, and market growth. These policies have been organized based on a template of policy initiatives that were developed over the last several decades to help the high technology sector grow. Thus, while environmental benefits will certainly accompany this sector's growth, success in this context will be measured in terms of businesses formed, jobs created, and dollars earned, rather than in amounts of energy produced or conserved.

This approach to the clean energy sector, focused as it is on jobs and investment rather than energy use as the ultimate goal, is somewhat nontraditional. But it is the hope of the project sponsors that the policy initiatives suggested here (all of which are operating in some form already and may be expanded or adapted to meet clean energy businesses' needs) will give the clean energy sector the support it needs to thrive in the 21st century.

Background: The High Technology Sector

Over the last 20 years, high technology has come to define an increasing portion of the economies of Washington, Oregon, and British Columbia. The technology sector has been the fastest growing in each area, with significant increases in jobs and substantial spin-off benefits to local economies. The sector – which consists of electronics, software, Internet com-

merce, wireless applications, and biotechnology – accounts for 10% of Washington's job base, half of Oregon's total exports, and 3% of the British Columbia economy.[1]

A number of analysts, including local economist Paul Sommers,[2] have concluded that actions taken by local and regional governments have encouraged the development of the high tech sector and have assured not only its continued success in general but its continued success in this region. They point to initiatives ranging from investment in education and research to R&D-focused tax incentives, and even the development of neighborhood and cultural amenities as important factors in helping technology-based businesses form, develop, and grow.

The Clean Energy Sector

According to the draft market analysis prepared for Climate Solutions by Compass Resource Management and Planit Management, the global market for clean energy equipment and services is expected to average $180 billion per year over the next two decades. This market, which is about twice the size of the passenger and cargo aircraft industries over the period, is comprised primarily of energy efficiency technologies and services, with the remainder made up of renewable energy production and distribution technologies. These assumptions about the size of the industry are conservative in that they assumed no major changes in government policy in response to air pollution, global warming, or energy costs that might tend to provide even greater stimulus to renewable energy and energy efficiency products and services. Because of the technology-oriented nature of many clean energy businesses, many of the approaches governments took with earlier technology businesses may also prove effective in helping clean energy businesses succeed.

For the purposes of this project, clean energy has been defined to include two different but related industries:

Energy Efficiency. Energy efficiency businesses offer products and services designed to help consumers use traditional energy sources more efficiently. Energy service companies and engineering firms provide energy management services, while other energy efficiency businesses focus on lighting, building systems, and controls. According to the market analysis, energy efficiency currently makes up about 3/4 of the clean energy industry in the Pacific Northwest, and is anticipated to be a $200 billion dollar industry worldwide by 2020. Fuel cells and power systems – technologies that use existing power sources significantly more efficiently – may also be considered part of this sector, and could, according to the market analysis, have global markets equal to nearly $500 billion by 2020.

Renewable Energy. Renewable energy is defined as sources of energy that derive from inexhaustible resources and which minimize environmental harm when used. Renewables are generally considered to include solar, wind, geothermal, biomass, and small hydro sources of power. According to the market analysis, total global investment in these technologies could increase from $100 billion to $300 billion between 2000 and 2020.

The Pacific Northwest's clean energy sector contains a number of different firms and technologies. According to the Compass/Planit market analysis, most technologies are represented in some form, although the region has particular competitive strengths in fuel cells, power system technologies and solar photovoltaics. According to the analysis, the sector as a whole in the Pacific Northwest currently represents about $1.4 billion in annual sales and some 6,000 jobs, and could expand by 2020 – even assuming no major investment due to global warming or other clean air policies – to a nearly $4 billion industry with over 18,000 local jobs.

The market analysis notes that fuel cells present a significant opportunity for the Pacific Northwest to establish leadership in an industry as the potential market is large, the technology is just at the point of commercialization, and the region has a number of dominant firms. Power system technologies could benefit from technological advances, system standards, market restructuring, and customer demand. Solar

1 "Analysis of High Technology Policy Initiatives in the Pacific Northwest and British Columbia," prepared by Steeple-jack Consulting for Climate Solutions, April 2001.

2 Sommers, Paul, Daniel Carlson, Brookings Institution Center on Urban and Metropolitan Affairs, Washington DC, "Ten Steps to a High Tech Future: The New Economy in Metropolitan Seattle," December 2000.

power is expected to become a significant global energy provider, and the Northwest is well positioned to become an industry leader. In the short to medium term, energy efficiency and wind power appear to offer the most aggregate economic activity and greatest development potential for regional economies.

The analysis determined that these technologies formed a logical cluster and offered the greatest chance for the Pacific Northwest to establish an export industry. Other technologies will continue to be installed locally and create installation jobs, but in some cases (such as wind) the bulk of the manufacturing will likely remain elsewhere. Key criteria considered in evaluating the industry development potential of each technology were: 1) overall market size; 2) technology and workforce synergies; 3) stage of technology development; 4) competitive position of the Pacific Northwest; and 5) economic leverage of the technology.

Possible Policy Initiatives

The Pacific Northwest has a thriving clean energy industry comprised of a range of different technologies, products, and services. To help these businesses grow, this paper focuses on public policy initiatives that could help technology-based clean energy businesses, particularly those in the areas targeted by the market analysis, to develop new technologies, commercialize those technologies, and develop markets for their new products. The policies suggested here are intentionally modeled after policies that were developed and implemented for other technology-based businesses. They include:

Technology Development

Policy Opportunity 1: Increase funding for energy technology research centers at public universities or publicly funded laboratories.

Policy Opportunity 2: Provide resources, policy and legislation to strengthen the growth and development of applied research laboratories for emerging businesses, where clean energy businesses can test new technologies and begin the process of commercialization.

Policy Opportunity 3: Strength and modify existing technology R&D tax incentives to make certain they are useful to energy technology businesses.

Commercialization

Policy Opportunity 4: Establish a clearinghouse for clean energy businesses so that they can be identified and aided by public and private business assistance organizations, and support the development of clean energy business associations.

Policy Opportunity 5: Support the growth and development of clean energy-oriented business incubators to help emerging businesses develop applications for their technologies, develop business plans, and find investment capital.

Policy Opportunity 6: Provide opportunities for clean energy entrepreneurs to receive formal management training, business startup training, expert business counseling, and help in making business alliances with suppliers, distributors, and large business customers of their products.

Market Development

Policy Opportunity 7: Create incentives for 'early adopters' to purchase and use renewable energy and energy efficiency products.

Policy Opportunity 8: Strengthen government procurement and regulatory policies to broaden the market for renewable energy and energy efficiency products.

Policy Opportunity 9: Create requirements for utilities to purchase clean energy through one or more of the following: Renewable Portfolio Standards; systems benefit or public purpose charges; or carbon standards that allow mitigation dollars to be used to support clean energy technologies.

Policy Opportunity 10: Expand 'market transformation' activities to take renewable energy and energy efficiency products and services beyond early adopters to ordinary consumers.Businesses based on the application of new technology need opportunities to develop and test that technology. It is not surprising, then, that many biotechnology businesses have grown up close to hospitals and research laboratories, or that many high tech startups locate near university campuses to be close to the researchers from whom the technologies originated.

Technology Development

As the Compass/Planit market analysis points out, the Pacific Northwest is well prepared to lead in technology development efforts in the clean energy industry. The region has a sizeable pool of skilled labor as well as strong existing high technology clusters, and the investments made for high tech in education, R&D, and training over the last several decades should also benefit the clean energy sector.

The market analysis notes that the region has established technological leadership in three areas – fuel cells, power systems, and solar power – and has existing or nascent technological clusters in several additional fields including small hydro, biomass, and energy efficiency products.

Because of the technology focus of many of the region's clean energy businesses, additional efforts on the part of government to assist with technology development could be quite valuable. Work of this nature is already underway in several clean energy fields. It could be expanded and, perhaps, even regionalized, to help existing and new clean energy businesses form technology clusters and develop and test new products.

POLICY OPPORTUNITY 1:

Increase funding for energy technology research centers at public universities or publicly funded laboratories.

This type of investment could take regional form, or could be accomplished through the establishment and funding of individual research centers. There are already several existing clean energy-focused research centers that could serve as examples for the creation of new centers.[3]

The National Research Council of Canada's Innovation Centre, which is located at the University of British Columbia, has created a Fuel Cell Research Facility as part of Canada's National Fuel Cell Research and Innovation Initiative. This research center is expected to help Canada develop its fuel cell industry through strategic research initiatives. The center was created in 1999 with a $30 million (Canadian) federal government investment.

Washington's Pacific Northwest National Laboratory (PNNL) which is one of nine U.S. Department of Energy laboratories, conducts basic research in environmental science and technology. The lab often works with Energy Northwest (a utility) and with local business incubators to help commercialize new technologies. During 2000, PNNL's business volume was $520 million (US).

POLICY OPPORTUNITY 2:

Provide resources, policy, and legislation to strengthen the growth and development of applied research functions for emerging businesses, where clean energy businesses can test new technologies and begin the process of commercialization.

Some organizations, rather than performing basic research, focus their efforts on the specific research and technology needs of emerging businesses. Such organizations can provide a valuable role in helping scientists and entrepreneurs develop applications for new technologies and begin the process of commercialization.

One example of this type of organization is the Washington Technology Center (WTC). The WTC was formed by the Washington State Legislature in 1983 to help facilitate technology development and commercialization, with a specific focus on the economic benefits of high tech to the state and its citizens. The WTC works with both the University of Washington and Washington State University, and has formed partnerships with over 75 local businesses, more than half of which have less than ten employees. The WTC operates as something of a hybrid between a pure academic research center and a business incubator, serving as a go-between to identify small companies' areas of needed research and expertise.

The WTC and Applied Process Engineering Laboratory (APEL) recently collaborated to create a proposal to found a Center for Energy Technology

3 Please note that in this discussion as throughout the paper, examples of existing programs are cited to describe the kind of program or effort the policy opportunity espouses. These lists of existing programs are not intended to be exhaustive, but are rather used to illustrate specific features and programs, and therefore do not include every program or initiative that exists.

Commercialization. This center, for which they are seeking $6.875 million in federal funds for five years of operation, would give small energy businesses access to technology, engineering and testing resources; financial resources to 'prove out' their products in a scaled-up capacity; and access to qualified investment. The Spokane Intercollegiate Research and Technology Institute (SIRTI) would add a commercialization component to the center.

POLICY OPPORTUNITY 3:

Strengthen and modify existing technology R&D tax incentives to make certain they are useful to energy technology businesses.

Over the last decade, the governments of British Columbia, Oregon, and Washington have offered tax relief programs to high technology businesses to encourage research and development functions. These programs have been designed to help high tech businesses invest in new facilities and pursue new research.

British Columbia has an income tax that is levied on both individuals and corporations. The income tax on corporations was targeted in the province's Scientific Research and Experimental Development Tax Credit Program. This program provides a 10% tax credit to qualifying corporations that carry on research and development in BC after August 31, 1999. The corporation's expenditure limit is $2,000,000. Canada defines research and development as including experimental development, applied research, and basic research, any of which could include energy technology research. However, the program does NOT cover commercial production of a new or improved material, device, or product or the commercial use of a new or improved process, which may limit its usefulness to business applications.

Oregon offers a Strategic Investment Program, which exempts a major portion of capital investments over $100 million from property taxes for 15 years. The local government must approve the project, and the manufacturer must pay a community service fee equal to 25% of the abated taxes, up to a maximum of $2 million annually. The manufacturer must also enter into a first-source hiring agreement with a publicly funded training provider. The program was implemented in large part for Intel, to help it develop two state-of-the-art facilities during the mid-1990s. As 'environmental services' is included in the list of eligible key industries, clean energy firms could potentially avail themselves of the program, assuming they were entering into capital investment projects large enough to qualify given the program's $100 million investment threshold.

Washington State has two tax relief programs for high technology businesses. Both of these tax programs can be used by energy technology businesses. The High Technology Business & Occupation (B&O) Research and Development Tax Credit offers an annual credit against the Business & Occupation tax bill of up to $2 million for businesses that perform research and development in specified technology fields. This tax credit was used by 838 firms between January 1995 and February 2000, claiming a total of $115.6 million in tax credits. During this time, 179 environmental technology firms received a total of $4.3 million in tax credits. The second tax program, the High Technology Sales/Use Tax Exemption, allows businesses to be exempted from sales or use tax for pilot scale manufacturing facilities. Between January 1995 and February 2000 253 firms used this tax program, receiving deferrals or exemptions worth $231.5 million. Only 5 projects – worth just over $125,000 – were claimed by environmental technology firms.

Commercialization

The Compass/Planit market analysis cites lack of investor interest as a key barrier to the growth of the Northwest's clean energy sector. According to investors interviewed by the research team, clean energy businesses tend to be managed with a technology focus rather than a customer focus, often with no business plan or market knowledge. This finding is backed by the National Renewable Energy Laboratory (NREL), which has found that many clean energy businesses fail during the transition between technology development and commercialization. The commercialization phase is complicated for clean energy businesses by the fact that many products and services must meet product certification requirements to be used as part of the power grid.

Government organizations in Washington, Oregon, and BC assisted the high technology sector both by direct mentoring and by funding the startup costs of business associations that could help individual businesses through this transition, supporting them in networking, marketing, and pursuing venture capital. These associations have also allowed individual businesses to act together to lobby for changes to state or provincial law.

Governments and utilities have already provided support to a number of clean energy-oriented business associations. The Northwest Energy Efficiency Alliance, which is funded by BPA and Northwest utilities, for example, focuses on encouraging the acceptance of energy efficient products in the marketplace. And Fuel Cells Canada, which is housed at the University of British Columbia's Innovation Centre and was launched with federal and provincial funding, is a non-profit organization that will collaborate with government, the private sector and educational institutions to encourage a cluster of manufacturers and service suppliers for existing and new fuel cell systems developers.

POLICY OPPORTUNITY 4:

Establish a clearinghouse for clean energy businesses so that they can be identified and aided by public and private business assistance organizations; and support the development of clean energy business associations.

During interviews about their work, several representatives of business associations and incubators noted that working with emerging clean energy businesses poses a challenge simply because it is often difficult even to find them. Because clean energy – particularly energy efficiency – spans several SIC classifications, these businesses are often grouped under disparate categories and are therefore difficult to identify. State/provincial governments could do a real service to the sector by developing better mechanisms for identifying businesses working in clean energy.

Once businesses are identified as being part of a specific sector, they can be aided by research organizations, incubators, or business associations. Several of the existing high tech sector business associations in the region were formed with start-up funding provided by government agencies. These associations help their members through networking and continuing education opportunities, lobbying, coordinated approaches to venture capital, and joint marketing and outreach campaigns.

It may be possible to incorporate clean energy businesses within existing high tech business associations. Washington's Technology Alliance, for instance, has formed an Energy Subcommittee, which is focused both on updating its members about the energy situation and on identifying new energy technologies.

BC's Technology Industries Association has already incorporated some aspects of the clean energy sector into its operations. Xantrex Technology, QuestAir Technologies, NxtPhase Corporation, Ledalite Architectural Products, and Ballard Power Systems are all members of the organization, and an 'alternative energy' membership category will be added soon to accommodate the interests and needs of these firms.

On the other hand, individual clean energy technology clusters may wish to create or broaden business associations specifically focused on their own needs. In either case, government may be able to help by identifying businesses within the same industry, by providing information about resources that are available to help them, and by funding the startup costs of new business associations.

Identifying existing businesses involved in clean energy and renewable energy products and services could allow local governments to help these businesses fill gaps in local demand. As Pacific Northwest residents increasingly look to purchase sustainable products and services, government could help businesses identify items that are being imported from other regions, and thus encourage import substitution within known markets. As businesses are identified, government could also help identify market opportunities with existing trading partners overseas, building on other economic development and trade development efforts.

The Northwest Energy Innovation Center (NWEIC), which has just been launched by Bonneville Power, Energy Northwest, Washington State University, and Battelle Pacific Northwest National Laboratory, may help fill some of this function in Washington. The NWEIC aids innovators in preparing their products for commercial use by providing access to the electric grid, access to the engineering and technical staffs of utilities and other resources of actual commercial users. As a result, their products will be ready to meet existing commercial need when developed. The NWEIC provides experienced project managers who champion the innovators' technology and help steer its development to meet the needs of commercial users.

POLICY OPPORTUNITY 5:

Support the growth and development of clean energy-oriented business incubators to help emerging businesses develop applications for their technologies, develop business plans, and find investment capital.

Recent research conducted on the clean energy sector by the National Renewable Energy Laboratory (NREL) shows that many clean energy businesses are not prepared to make the jump between product development and marketing. Many businesses fail during this transition, NREL has found, because they are focused on technology rather than on commercialization. In response, NREL has launched the National Alliance of Clean Energy Business Incubators. NREL is currently pursuing two incubators, in Texas and California, in collaboration with local research institutions. One or several Pacific Northwest clean energy business incubators could be formed in collaboration with the region's colleges, universities, and research centers. A business incubator could be formed in partnership with NREL or could be pursued independently. The Spokane Intercollegiate Research and Technology Institute (SIRTI) is pursuing a partnership with NREL.

Several existing incubators in the region already serve clean energy businesses. The Spokane Intercollegiate Research and Technology Institute (SIRTI) began from a startup grant received from the DoD in 1995 and resulted in the creation of an independent Washington state agency in 1998. The organization educates entrepreneurs and helps with market research and business development in the fields of biotechnology, digital technology, and energy technology. SIRTI does not involve itself in R&D, but rather focuses on investor needs and interests, helping businesses find venture capital and markets for their products. SIRTI staff point to their success in clean energy in their role assisting Avista Labs, now one of the national fuel cell leaders.

The Applied Process Engineering Laboratory (APEL) incubator has clean energy development and commercialization projects underway in micro-fuel cells, solar, power conversion and others. APEL is working with Energy Northwest and the Northwest Energy Innovation Center to promote commercialization of new clean energy technologies.

Not all incubators are publicly funded. Smartstarters is a private incubator that receives its funding by taking a small equity stake in the businesses it assists. It recently moved into the clean energy sector, noting that the market will supplement publicly funded initiatives where there is demand.

POLICY OPPORTUNITY 6:

Provide opportunities for clean energy entrepreneurs to receive formal management training, business startup training, expert business counseling, and help in making business alliances with suppliers, distributors, and large business customers of their products.

Because emerging high tech businesses are often small enterprises with several scientists or technologists and no management team, a number of 'Technology Management' degree programs have been created around the region in recent years. A similar effort –

offering management training in Energy Technology – could help provide qualified management expertise to new clean energy businesses or allow leaders at existing businesses to develop needed financial and management skills.

Formal programs offered through private or public universities could be supplemented with opportunities for clean energy entrepreneurs to learn about and then present to representatives of venture capital firms. Such sessions, which could be organized by government agencies (by Economic Development or Energy Departments) or by business associations or incubators, could allow clean energy businesses to develop the skills and attributes required by investors.

Forums such as Entrepreneur University hosted by the non-profit Northwest Venture Group could help new business leaders gain information and skills to develop workable business plans and funding presentations.

Market Development

According to the Compass/Planit market analysis, small power producers throughout the region face barriers in obtaining access to transmission and distribution grids, which make it difficult for them to compete with other energy sources. These problems, according to the market analysis, increase clean energy's perceived risk and uncertainty in the eyes of investors and limit clean energy's availability to consumers and make market development a real challenge.

Governments can pursue several policies to assist clean energy businesses in this area:

POLICY OPPORTUNITY 7:

Create incentives for 'early adopters' to purchase and use renewable energy and energy efficiency products.

Early adopters are individuals, businesses, and agencies that purchase and use new technologies in the early stages of their commercialization. Early adopters are well known in the technology sector, where they form markets for new gadgets, software programs, and technologies. In the clean energy sector, early adopters can be a key part of commercializing and marketing a product or service. Early adopters can not only provide real-world test marketing for new products and services, but can also build product awareness among the general population through example and word of mouth.

A number of utilities and governments have established programs to encourage early adopters to purchase and use renewable energy and energy efficiency products and services.

PacifiCorp's 'Blue Sky' Program, for example, allows the utility's Oregon customers to add a voluntary surcharge to their electric bill to purchase wind energy. Consumers elect to buy a certain number of blocks of renewable power for $2.95 per 100 kwh block per month. PacifiCorp commits to use the additional funds to buy down the cost of wind power. Currently, some 6,000 customers, or approximately 0.5% of PacifiCorp customers participate in the program, purchasing 11,000 blocks for a total of 1.1 million kwh per month. PacifiCorp estimates that purchasing one 100 kwh block of Blue Sky each month for a year has the same environmental benefits as not driving a car for 1,800 miles or planting 1/3 acre of trees. The Blue Sky program will be continued for at least the next two years, but then will be changed as Oregon's new mandatory public purposes charges for power go into effect (see Policy Opportunity 9). Whatever its future, the program has served a purpose in providing an opportunity for early adopters to subsidize the cost of renewable energy development before all consumers in the state were required to do so.

The State of Oregon offers three tax incentives for early adopters of renewable energy and energy efficiency. The Residential Tax Credit (RTC) offers a state income tax credit of up to $1,500 to consumers who install renewable energy features, such as solar panels, or purchase energy efficient products or services, such as front-loading washing machines, hybrid vehicles, etc. The Business Energy Tax Credit, which was established in 1980, allows businesses a credit against 35% of the eligible cost of acquiring and using renewable energy or energy efficient products and services less than 25 MW. The Small Scale Energy

Loan Program offers fixed-rate, low interest loans to individuals and businesses that are installing renewable or energy efficient features worth between $30,000 and $30 million.

POLICY OPPORTUNITY 8:

Strengthen government procurement and regulatory policies to broaden the market for renewable energy and energy efficiency products.

Government agencies can help broaden the market for renewable energy and energy efficient products and services beyond early adopters both through their own purchases and through their regulatory policies. Government agencies are significant purchasers of products and services. Governments build and operate buildings and a wide range of other facilities, purchase and operate fleets of cars, trucks, and other vehicles, and purchase hundreds of thousands of computers, printers, and other types of equipment. Through their purchases, government agencies can create a market for new and emerging technologies, as well as for existing products (such as energy efficiency products and services) that have not yet established themselves in the marketplace, but that have proven their ability to generate cost savings over the life of the product. U.S. Federal agencies are directed by the Energy Policy Act of 1992 and an accompanying Executive Order to identify and purchase energy efficient products whenever possible. As Federal agencies spend an estimated $10-$20 billion a year on energy-related products, and $7 billion a year in energy bills, cost savings – and benefits to clean energy firms – can be significant.

Earlier this year, the State of New York initiated the most ambitious of this type of program in the U.S., mandating that state buildings get 20% of their electricity from renewable sources such as solar or wind power by 2010. The new policy is expected to give an important boost to fuel cells and other alternative energy technologies.

In addition to changing their own energy use patterns, government agencies can encourage energy efficiency or use of renewable energy sources in the private marketplace through their regulatory powers. The City of Seattle's proposed 2001 Seattle Energy Code, for example, would require privately developed nonresidential buildings to be 20% more energy efficient than the national standard. Seattle City Light estimates that this policy, if adopted, could save between 1 and 1.5 average MW, enough to supply 12,000 homes for a year.

More widely adopted procurement and regulatory policies could give clean energy businesses access to a significant market while, at the same time, educating the public about the true costs of energy use and about ways to use energy more efficiently.

POLICY OPPORTUNITY 9:

Create requirements for utilities to purchase clean energy through one or more of the following: Renewable Portfolio Standards; systems benefit or public purpose charges; or carbon standards that allow mitigation dollars to be spent to support clean energy technologies.

The Compass/Planit team's market analysis concluded that utility-imposed barriers to clean energy firms often emerge in execution if not in policy. That is, despite commitments to conservation and use of alternative energy sources, utilities may in fact impose barriers through long delays, pricing structures that do not reflect the full cost of energy sources, a lack of profit incentive on the part of regulated utilities to invest in new technologies, and restrictions on access to transmission. These issues will all need to be addressed, but can be approached first through policies that require utilities to add renewable resources and energy conservation to the mix of power they provide.

The following three potential programs would each take a different approach to this goal.

Renewable Portfolio Standards

A Renewable Portfolio Standard is a policy that obligates each retail seller of electricity to include a certain amount of electricity from renewable energy resources such as wind, solar, geothermal, or small hydro. This requirement can generally be satisfied either by owning a renewable power facility or by purchasing power from a clean energy producer. In some cases, utilities can trade their renewable obligation.

The State of Texas under Governor (now President) Bush instituted what is widely considered to be the

most effective Renewable Portfolio Standard in the U.S. Texas' program has stimulated the development of some 600 MW of new wind energy projects and 100 MW of other renewable energy projects.

Several governments and utilities in the region have adopted some variation on this program. BC Hydro's Energy Futures Program, for instance, has committed to meet up to 10% of new demand over the next 10 years with renewable energy.

Systems Benefit or Public Purpose Charges

According to a Union of Concerned Scientists report, nineteen states including Oregon have implemented systems benefit charges (also known as public purpose charges or public benefits funds).[4] Systems benefit charges are small surcharges paid by consumers in addition to their utility bills. The surcharges are used for any of a number of public purposes, but usually are focused on buying down the cost of new clean energy technologies.

These programs take the voluntary surcharges paid by early adopters – such as PacifiCorp's 'Blue Sky' program – and make them universal, using small payments from hundreds of thousands of consumers to make new technologies more viable. California's system benefit charge, the largest in the United States, is anticipated to raise $540 million between 1998 and 2002, an amount on par with many national clean energy programs.

The State of Oregon's public purposes charge was established in 1999 and takes effect in spring 2002. The program requires utilities to devote 3% of their gross sales (estimated to be $72 million each year) to a series of public purposes: 10% of the fund will go to schools, 11% to low income weatherization programs, 4.5% to low income housing construction, 17% to the development of renewable energy resources, and 54.6% to conservation initiatives. The renewable energy and conservation aspects of the program are administered by Energy Trust of Oregon, a non-profit organization. Systems benefit charges give clean energy businesses a way to offset the market price of their technologies. Similar programs could be implemented throughout the region.

Carbon Standards

A number of jurisdictions and utilities have begun to implement voluntary or mandatory carbon standards, by which increased greenhouse gas emissions from new or expanded power plants are mitigated. Typically, these standards are met through some sort of 'offset' for the additional carbon dioxide through tree planting projects or conservation measures. Carbon offsets can also be used to build or purchase renewable resources, a move that could provide market opportunities for clean energy businesses.

The State of Oregon's Energy Facilities Siting Rule, for instance, requires that any new power plant constructed in Oregon must be 17% more efficient than the most efficient power plant in the United States. To meet this standard, power plant operators whose emissions exceed this level must find ways to sequester carbon or pay for 'offset' projects. The program is administered by the Energy Facilities Siting Council, which permits offsets to take the form of renewable resources or donations to the Oregon Climate Trust, which can, in turn, invest in renewable energy, energy efficiency, transportation, or carbon sequestration projects.

In British Columbia, BC Hydro's GHG Offset Program commits the utility to offset 50% of the increased greenhouse gas emissions from two new gas-fired generating plants on Vancouver Island through the year 2010.

Seattle City Light in Washington State, has also begun purchasing carbon offsets to meet the City of Seattle's Earth Day Resolution calling for zero net greenhouse gas emissions.

Adopting state- or province-wide carbon offset policies – similar to Oregon's – and allowing carbon offsets to be purchased in the form of investment in

4 "Clean Energy Blueprint, A Smarter National Energy Policy for Today and the Future," Union of Concerned Scientists, Tellus Institute, Phase I (Revised), June 20, 2001

clean energy applications and technologies could provide a valuable market for clean energy businesses with tested and effective applications.

POLICY OPPORTUNITY 10:

Expand 'market transformation' activities to take renewable energy and energy efficiency products and services beyond early adopters to ordinary consumers.

Governments and utilities can use their purchasing power to stimulate the development of new technology and provide a launching pad for new products. But, over the long term, clean energy businesses generally need the support of private consumers to succeed. Although individual consumers may not make the decisions about what type of power a utility purchases, they do influence those decisions. And, of course, individual consumers make a myriad of personal and business decisions – to install a solar-powered water heater, buy an energy efficient washing machine, install compact fluorescent lighting, or sell electricity back to the grid – that will ultimately determine whether clean energy businesses succeed and thrive.

Over the last decade, a number of governments and utilities have become involved in what they call "market transformation" activities, helping develop brand awareness of renewable energy and energy efficiency products among consumers and businesses. They may offer referrals or issue rebates or may actively participate in developing a brand identity. Expanding and strengthening these programs could be key in helping clean energy technologies move beyond niche status in the marketplace.

The most well-known of these efforts is U.S. EPA's "Energy Star" certification, which is used by governments and utilities around the U.S. But a number of other market transformation programs exist and could be augmented by local and regional efforts to help the Northwest's clean energy industry.

In energy efficiency, the Northwest Energy Efficiency Alliance is a utility-sponsored effort to bring energy efficient products and services to consumers. The Alliance provides financial incentives, conducts market research, and offers marketing assistance, with the notion that once the market is "transformed," incentives will no longer be needed. The Alliance plans to spend $100 million between 2000 and 2004 on market transformation activities.

Local government agencies can become part of market transformation as well. Seattle City Light's Conservation Kits, for instance, provide electric customers with a set of vouchers for energy efficient products and services so that consumers can test these new products.

Conclusion

Over the last several decades, the high technology sectors in Washington, Oregon, and British Columbia have grown and thrived. Clean energy technologies – in renewable energy sources and energy efficiency products and services – have grown as well, and have the potential to add thousands of new jobs and billions of dollars in sales to the region's economy.

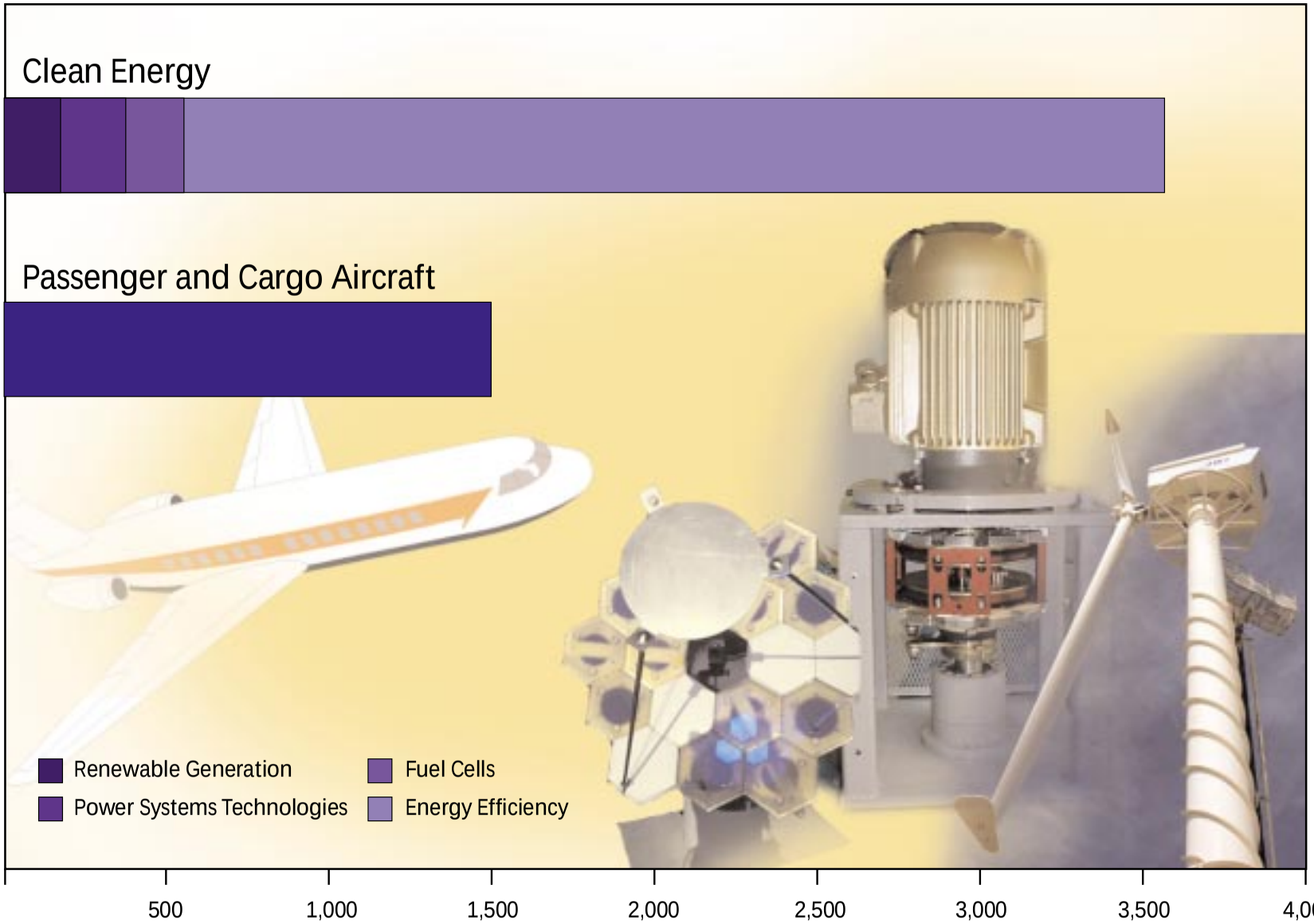
Helping these businesses grow is not necessarily complicated. After all, governments around the region have been involved with the high tech sector for decades and have implemented a range of programs to help technology businesses. But helping the clean energy sector grow will require commitment from governments throughout the region.

Appendix

Table 1: Legend

	←		→
	Less attractive		More attractive
			
Size, accessibility and growth of key markets	Accessible markets are <$1 billion per year by 2010	Accessible markets are 1-5 $billion per year by 2010	Accessible markets are >5 $billi 2010
Stage of Technology Development	Either 1) too early (i.e. no commercial potential until after 2010) or 2) too late (i.e. further opportunity for Pacific Northwest to innovate and add value is already limited).	Product has commercial potential now, but the technology will be fairly mature by 2010.	Significant commercial growth is 2010, and product developments significant beyond 2010.
Competitive position of Northwest	Competitors are large, well funded and well ahead of any companies currently in the Pacific Northwest (Pacific Northwest is "behind the pack")	Competitive landscape is somewhat established, but technology developments are still rapid (Pacific Northwest is "middle of the pack")	Competitive landscape is somev and Pacific Northwest has a lea (Pacific Northwest is "ahead of t
Economic leverage	Largely a service industry, or a local installation industry (i.e. most of the installed cost is taken up by installation of the product)	Largely a manufacturing opportunity, but skill levels and shipping costs will likely favour location of facilities closer to customers by 2010.	A combination of R&D, testing a manufacturing. Some product li near customers by 2010, but the skills and value could take place Northwest.
Synergies with other energy technologies	1-2 similarities / synergies with other clean energy technologies (i.e., relatively stand-alone technology).	3-4 similarities / synergies with other clean energy technologies (i.e., some linkages in design, manufacturing technology, inputs, skills, and markets).	5 or more similarities / synergies clean energy technologies (i.e., a candidate for forming part of a la cluster).
Workforce Synergies	Majority of product is low tech and does not draw on indigenous Pacific Northwest skill sets	Product uses some advanced technology and draws on indigenous Pacific Northwest skill sets	Majority of product is some com advanced materials, electronics, design, photonics or communica
Local supply potential	Limited economic supply potential in Pacific Northwest by 2020 (<$500 million investment by 2020)	Technology is already (or soon to be) economic in the Pacific Northwest, but investment potential is <$10 billion by 2020.	Technology is already (or soon t in the Pacific Northwest, and inv potential is > $10billion by 2020.

Relative Size of Clean Energy Industry



Global Sales from 2000 to 2020 ($ Billions)

(Sources: Rolls Royce, IEA, ADL, ONL, EREN, EU ATLAS)

New Job Growth Potential in the Clean Energy Industry Over the Next 20 Years

(Sources:Compass Resource Management, Planit Management, EUFORES)

Note: Projection of job growth "Without Government and Investor Support" based on this report's economic projection of $2.5 billion average annual sales for the Pacific Northwest by 2020. Projection of job growth "With Government and Investor Support" based on implementing government policies and encouraging investor support with a goal of the Northwest capturing 3.5 percent of the $180 billion in average annual sales in the global market by 2020 projected by this report. Both sales projections are applied to a factor of 5 jobs/per $1million as derived from the European Forum for Renewable Energy Sources' (EUFORES) 1999 report: "Impact of Renewables on Employment and Growth".

Notes on assumptions for Market Analysis

Assumption	Details and Sources	Comments
Wind, solar, biomass, geothermal projections	Regional current data and forecasts are from IEA World Energy Outlook 2000. Figures for 2000 are interpolated between 1997 and 2020. Figures for subregions (e.g. Pacific Northwest, Germany etc) are obtained through a combination of government and industry sources, and from interpolations of wider regional data.	As mentioned in the text box: "A Note on Energy Forecasts", IEA tends to be relatively conservative in its forecasts of change in the energy industry, and, therefore, in its forecasts of the uptake of clean energy.
Small hydro projections	Regional data primarily from EU ATLAS, are extrapolated from 2015 to 2020. Local data are from various local sources (utilities etc.), including the EIA's small hydro inventory. The 2020 small hydro figure for India was developed based on the EU ATLAS note that approximately 4.4% of installed hydro plants are small hydro.	In its World Energy Outlook, IEA does not differentiate between large and small hydro, hence further sources were consulted to determine the breakdown.
Fuel cells projections	Market projections are based on a combination of sources. The National Fuel Cell Research and Innovation Initiative estimates that by 2020 a total of $75 billion of fuel cells will have been purchased in the transportation sector, $25 billion in large power generation and $6 billion in small and portable power generation. Primen cites more aggressive sources that put the global market for stationary fuels cells alone at $20 Billion as early as 2010. And ADL estimates that investment in US commercial building fuel cell applications alone could be $10 Billion by 2010.	Fuel cell markets in the transportation sector are allocated among the major vehicle manufacturing nations according to the current distribution of existing manufacturing capacity
Power system technologies projections	Power system technology market sizes are based on IEA infrastructure projections by region. Further allocations by type of technology were made based on investment patterns (per Pacific Northwest Lab) as follows: Storage systems: 0.5% of total installed capacity, Control systems: 1.0% of total installed capacity, Communications systems: 0.5% of total installed capacity.	These figures are conservative compared to private industry projections of future investment.
Energy efficiency technologies / services projections	EREN (1995) notes that: The renovation component of the building sector (i.e. 2.67% of GDP) would be partly made up of energy efficiency technologies and/ or services: 10% is the figure assumed here (i.e. energy efficiency sales are assumed to be 0.267% of GDP). Regional market size estimates are adjusted up or down to reflect per capita incomes, climate and energy costs.	Building retrofit activity is used as the basis for characterizing an "energy efficiency" market, since most recognizably energy efficient products are aimed at this market. Other technologies, of course, exist that improve efficiency (e.g. catalytic processes etc); however, to include all possible efficiency products would not be possible or meaningful.
Capital cost projections	Data on assumed capital costs and forecasted changes in capital costs (by technology) are taken from EIA.	

IEA regional definitions for Market Analysis

OECD Europe

Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

OECD North America

Canada and the United States of America.

OECD Pacific

Australia, Japan and New Zealand.

Transition Economies

Albania, Armenia, Azerbaijan, Belarus, Bosnia-Herzegovina, Bulgaria, Croatia, Estonia, Federal Republic of Yugoslavia, Former Yugoslav Republic of Macedonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Romania, Russia, Slovak Republic, Slovenia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan. For statistical reasons, this region also includes Cyprus, Gibraltar and Malta.

China

People's Republic of China, including Hong Kong.

East Asia

Afghanistan, Bhutan, Brunei, Chinese Taipei, Fiji, French Polynesia, Indonesia, Kiribati, Democratic People's Republic of Korea, Republic of Korea, Malaysia, Maldives, Myanmar, New Caledonia, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Thailand, Vietnam and Vanuatu.

South Asia

Bangladesh, India, Nepal, Pakistan and Sri Lanka.

Latin America

Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, St. Kitts-Nevis-Anguilla, Saint Lucia, St. Vincent-Grenadines, Surinam, Trinidad and Tobago, Uruguay and Venezuela.

Africa

Africa comprises Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Congo, Democratic Republic of Congo, Cote d' Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, United Republic of Tanzania, Togo, Tunisia, Uganda, Zambia and Zimbabwe.

Middle East

The Middle East region is defined as Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates and Yemen. It includes the neutral zone.

Major Sources for Market Analysis

Sources referred to in the text of this document:

ADL	Arthur D Little Profiles of Leading Renewable Energy Technologies for the Massachusetts Renewable Energy Trust http://www.mtpc.org/massrenew/adl.htm#
EIA	US Energy Information Agency www.eia.doe.gov
EREN	Energy Efficiency and Renewable Energy Network www.eren.doe.gov
EU ATLAS	European Union ATLAS Renewable Energy Overviews http://europa.eu.int/en/comm/dg17/atlas/html/renewables.html
EUROREX	Eurorex www.eurorex.com
IEA	International Energy Association (2000) World Energy Outlook www.iea.org
NREL	National Renewable Energy Laboratory www.nrel.gov
ONL	Oak Ridge National Laboratory www.ornl.gov
Primen	Primen www.primen.com
RNP	Renewable Northwest Project www.rnp.org
TERI	Tata Energy Research Institute www.teriin.org
US State Department	US State Department Country Commercial Guides http://www.state.gov/www/about_state/business/com_guides/index.html
USTrade	USTrade www.ustrade.org
WEA	World Energy Assessment (2000) UNDP / World Energy Council www.undp.org/seed/eap/activities/wea/

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Crew Development Corp., BC
Cyclus Envirosystems, WA
Dependable Turbines Ltd., BC
Energy Market Innovations, WA
GFI Ventures CA
Global Energy Partners, WA
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Heuristic Engineering Inc, BC
Idatech, OR
InnovaTek, WA
JX Crystals Inc., WA
Ledalite Architectural Products, BC
Lightyear Technologies Inc., BC
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